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ANALYSIS OF THE PRIVATE MARKET FOR LANDSAT PRODUCTS AND APPLICATIONS FINAL REPORT

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PREFACE

This report presents the results of a study by OAO Corporation and its subcontractor ECOsystems International Inc. for the National Aeronautics and Space Administration, Headquarters, Code ETS-6, Washington, D.C., under Task Order 25, Contract No. NASW3358. The study represents a comprehensive effort to analyze the U.S. private market arena and identify potential private users of Landsat technology. From the results of this study recommendations are made involving cooperative activities between NASA and the private sector, oriented specifically towards involving more of the private industrial users into utilizing Landsat derived data and information.

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1.0 INTRODUCTION AND OBJECTIVES

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1.1 INTRODUCTION

The Technology Transfer Division within NASA's Office of Space and Terrestrial Applications (OSTA) has the prime responsibility for transferring technology developed for the utilization of data from the Landsat family of satellites to all potential user sectors. Since the mid-seventies this division has developed programs designed to accomplish this transfer by providing assistance in adopting this technology to specific user sectors.

Until now the private sector has not been the focus of NASA programs and thus has had only minor involvement as a user in technology transfer activities to date. However, the private sector could evolve into a larger user sector than any of those involved in technology transfer activities to date, if it can become widely involved. For this reason, NASA has indicated a desire to devote more of its technology transfer efforts toward involving the private sector at all levels as users of Landsat technology. Such an investment could result in a significant increase in the overall utilization of Landsat technology.

This study is designed to provide NASA with a base line report on the private sector as a potential user of Landsat technology. Using this report, selected industries can be identified for further study and strategies can be developed for increasing the private sector market for Landsat-derived products and services. Included in this study is a detailed categorization and analysis of private sector industries based upon their potential uses of Landsat (or future satellite system) data. Moreover this study examines the previous involvement of the private sector as a provider of Landsat products and services.

1.2 STUDY OBJECTIVES

The primary goal of this study is to examine and evaluate the private sector to develop base line strategies and mechanisms for its increased utilization of Landsat (and future satellite) technologies as both consumer and producer of products and services. These strategies are designed

to be implemented by NASA in its current and future technology transfer programs. To accomplish this goal, the following are specific study objectives:

a. Categorize and evaluate the private sector to identify prime industries with existing and latent uses for remote sensing.

b. Assess the potential utility of the Landsat family of satellites for these uses now and in the future.

c. Identify, from a and b above, prospective current and future markets for Landsat technology.

d. Evaluate past case histories and precedents in private sector marketing of Landsat technology to underscore the "lessons" learned and prepare guidelines for current marketing strategies.

e. Determine the mechanisms by which NASA can promote the development of a viable Landsat products and services industry within the private sector.

f. Develop optimal strategies which NASA can implement for the marketing of Landsat technology in the private sector, based upon the characteristics of prime industries and past marketing methodologies.

1.3 ASSUMPTION CONCERNING IMPEDIMENTS TO PRIVATE SECTOR INVOLVEMENT

Until now, two widely recognized constraints have impeded the private sector from investing in or adopting Landsat technology. These two areas of concern are 1) data problems, i.e. timely data delivery, comparatively low resolution, and preprocessing inconsistencies, and 2) lack of a commitment by NASA or the federal government to a long-term satellite land remote sensing program.

For the purposes of this study the assumption was made that these constraints would be alleviated by the launch of Landsat D and the near-term commitment by the federal government to a future operational satellite land remote sensing program. Therefore, the strategies developed in this

study to involve the private sector do not consider these present day constraints.

1.4 CURRENT STATUS AND POTENTIAL FOR PRIVATE SECTOR UTILIZATION OF LANDSAT TECHNOLOGY

This section provides a background discussion of the status of private sector involvement in Landsat utilization to date and presents the outlook for future land remote sensing systems. It provides a frame of reference which is useful in understanding the role private sector can play in utilizing Landsat technology and how NASA can support this role. Two topics are presented in the subsections which follow: 1.4.1, a review of the Landsat system attributes and capabilities and, 1.4.2, a presentation of the applications in which the private sector has participated to date.

1.4.1 ATTRIBUTES AND CAPABILITIES OF THE CURRENT SYSTEM.

The Landsat series of satellites represents a technology that has made significant contributions to the information needs for resource management and decision-making in all sectors of society. Several characteristics of the information available from Landsat make its use attractive and appropriate for many private sector industries which do not currently use it. While these characteristics are generally well-known and understood, their reiteration in this report serves to reinforce the broad applicability of Landsat to the whole spectrum of private industry, and demonstrates its potential impact on this entire sector. Some of these characteristics are the following.

- Multi-spectral, synoptic perspective
- Repetitive coverage
- Digital format
- Standardized information
- Cost effectiveness
- Unique data source

- Multi-spectral Synoptic Perspective - The multi-spectral and synoptic chacteristics of Landsat data provide a unique viewing of the environment and provide information not available from any other conventional remote sensing technique. The Landsat multispectral scanner(s) (MSS) record energy reflected from the earth's surface in four

regions or "bands" of the electromagnetic spectrum: 0.5 - 0.6 micrometers (green), 0.6-0.7 micrometers (red), and 0.7-0.8 micrometers (infrared) and 0.8-1.1 micrometers (also infrared). The scanner collects the energy in each of these bands for every 57 by 79 meter ground area (about 1.1 acre), giving the MSS approximately 80 meter resolution. Landsat MSS data is provided in image or magnetic tape format for 185 by 185 kilometer ground areas or "scenes". The only other active imaging device on Landsat is the Return Beam Vidicon (RBV) camera system. The RBV images in only one broad band in the visible portion of the spectrum (panchromatic) and has an approximate ground resolution of 30 meters. RBV data is available in image format for ground areas one-fourth the size of MSS scenes.

- Repetitive Coverage - The repetitive coverage of Landsat is one of its most powerful capabilities, that permits users to monitor changes occuring over time for large land areas. Each Landsat satellite "images" a given ground location every 18 days. When more than one satellite has been in operation, their coverage has been staggered to provide coverage every nine days. Cloud cover significantly reduces the frequency of usable ground coverage, but several clear images per year are not uncommon for many areas.

- Digital Format - The digital format of Landsat has enabled a high degree of compatibility to be developed with computer processing and geobased information systems. This capability permits Landsat to be easily integrated and analyzed in conjunction with other sources of data for preparing comprehensive natural resources and land use planning and evaluation. The use of Landsat data with other sources of information has resulted in increased utility of total information systems.

- Standardized Format - In comparison to ground surveys and conventional aircraft coverages, Landsat data provides a more consistent, uniform and standardized information over large geographic areas

within a relatively short time period and with a common set of technical criteria.

- Cost Effectiveness - In many instances Landsat data have proven to be cost effective in providing large area land cover surveys and/or inventories, over using the conventional survey methods.

- Unique Data Source - For many uses, such as large land cover and natural resource inventories, Landsat provides the only available data to perform those tasks. Without Landsat, the cost, time, and manpower involved in compiling these inventories would often be prohibitive.

1.4.2 PRIVATE SECTOR PARTICIPATION IN LANDSAT APPLICATIONS TO DATE

Although the private sector participation in Landsat applications has been relatively limited as a whole, a variety of applications have had some involvement or at least interest by private businesses.

The largest user in the private sector of Landsat derived information has been the resource exploration industries - primarily for oil, natural gas, and mineral exploration. They have maintained a continuous interest in Landsat data, and have continued to expand their analysis of the data from photo interpretation techniques to their present interest in interactive digital analysis techniques.

The agribusiness industries have been very aware of the Landsat program and the government's R&D efforts (i.e. LACIE, AGRISTARS), however the private sector has been reluctant to actively use Landsat data to acquire information for their various resource management requirements. In the forestry industries there has been limited operational use of the data. A few of the larger corporations, with large land holdings, have conducted in-house R&D projects, and one company (St. Regis) is participating with NASA in an APT project at the present time.

The private companies involved in construction, real estate, and engineering which would involve geological, land use planning, or environmental mangement information have not put Landsat derived information to

much use. The larger companies, primarily in engineering and construction, have done some geological studies for siting of major construction projects, including railroads, highways, dams, and owner plants. However, most of these applicational efforts have been performed in the government sectors with very little participation from the private arena.

2.0 STUDY METHODOLOGY

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2.1 INTRODUCTION

The major objective of this study was the formulation of specific recommendations and action items to guide the extension of NASA Landsat technology transfer activities to include the private sector. The attainment of valid recommendations required a thorough analysis of the potential utilization of Landsat technology offered by the private sector as a producer and as a consumer.

These two groups, or market areas, within the private sector can be characterized by their modes of Landsat technology utilization.

The first market area is one of information producers and is comprised of remote sensing product and service business. This market is the segment of the private sector which employs remote sensing data directly as the raw material for the production of a salable product or service. Businesses within this industry use remotely sensed data, including Landsat, to provide the following: commercial supply of data products; supply of specially processed products, e.g., minitapes, special transformation and corrections; and the supply of intermediate products, e.g., Landuse maps.

The second market area for Landsat utilization is comprised of a very diverse population of business types. Many of these businesses do, however, have one thing in common, and that is their need for cartographic or geo-based information in their business activities. These businesses are sometimes interested in Landsat or other forms of remote sensing data per. se., but more often are interested in the higher levels of information which are produced from the processing and combination of remote sensing data with other forms of data. In this way, these businesses are consumers of remotely sensed data and products generated from it.

This study was structured to look at each of these two markets, the producers and consumers, within the private sector. In addition the foreign market was investigated to the extent that it may serve to stimulate U.S.

domestic industry interest and involvement with Landsat technology. Section 2.2 describes the methodology employed to examine the producers of remote sensing (Landsat) products and services in the private sector. In Section 2.3 the approach used to evaluate the potential private sector consumers or users of information derived from Landsat technology is presented. The methodology for assessing the potential foreign market for Landsat-derived products and services appears in Section 2.4.

2.2 REMOTE SENSING SERVICE INDUSTRY EVALUATION METHODOLOGY

Two approaches have been pursued in assessing the status of the remote sensing service industry. The methodology for performing the first, a look at selected case histories of companies which have supplied Landsat-derived products and services, is presented in Section 2.2.1. The methodology for the second approach appears in Section 2.2.2, and is an examination of the national mapping industry, in the context of this industry providing products (maps) potentially based upon Landsat or future satellite system data. The results of the remote sensing service industry evaluation are presented in Section 3.0.

2.2.1 DIGITAL ANALYSIS SERVICE INDUSTRY EVALUATION METHODOLOGY

The status of the remote sensing service industry market for Landsat was assessed by interviewing representatives and reviewing documentation of companies which have attempted to commercialize Landsat products and digital analysis services. This study approach has been used to permit the evaluation of prior marketing experiences of Landsat and kindred products. Included is an assessment of the reasons for marketing success or failure, so that sufficient parallels and lessons could be drawn to form guidelines for NASA in involving such establishments in future Landsat technology transfer programs.

The companies investigated include:

- o ERIM
- o ESL
- o Earthsat
- o General Electric

- o Lockheed
- o Bendix

2.2.2 METHODOLOGY FOR EVALUATING THE NATIONAL MAPPING INDUSTRY

The present and projected impact of Landsat and future satellites on the private mapping industry was evaluated by the following steps:

- o A determination of the types and volume of maps currently being produced by the national mapping industry;
- o Estimation of the growth of each map type to the 1990's;
- o Assessment of the role of remote sensing in the production of each map type;
- o Evaluation of the potential contribution of existing and planned Landsat-type platforms to mapping industry;
- o A determination of the fraction of national mapping activities performed by private industry;
- o Finally, the application of approximate dollar value of Landsat-derived inputs to mapping activities.

Government agency publications were used to gather statistics on the expenditures in the mapping industry and the portion which is given to the private sector. Map production volumes and trends for each map type and scale were determined from agency publications and interviews with personnel from the responsible agencies. This trend information was used to project map production into the 1990's.

The applicability of remote sensing to the production of each map type was evaluated in a three set process. First, the principal information elements required for production of each map type were identified from agency specifications. Second, the information elements were segregated into remotely sensed and non-remotely sensed categories. Third, the remote sensing band options (VIS, SWIR, TIR, as defined in Section 2.3.3) were evaluated for their ability to identify each remotely sensed information element. Each of these information elements was assumed to have equal

weight in map production, so that the contribution of each band option in the production of a map could be assessed. For example, if one of the band options provides 7 of the 10 information elements required for the production of a particular map, that option's potential contribution is 70%.

The contribution of each band option to each map type was multiplied by the estimated production volumes of each map type to obtain the equivalent number of maps potentially served by each band option. This is based upon the assumption that remote sensing inputs to different map types can be aggregated to produce "equivalent map units" as a means to get a rough measure of the impact of Landsat on mapping activities.

The applicability of remote sensing was further evaluated by assessing the sensor ground resolution required to support the production of maps at the scales of the various map types identified. The resolution required by each map scale was derived by consideration of technical standards adopted by the U.S. mapping industry.

The potential impact of Landsat upon the private mapping industry was then evaluated by first relating the spectral bands provided by current and postulated Landsat type platforms to the map information requirements and then relating the resolution provided by the Landsat-type platforms to the map scale requirements.

2.3 METHODOLOGY FOR ANALYSIS OF THE DOMESTIC USER MARKET FOR LANDSAT

The principal objective of this activity was to identify prospective, near- and far-term consumers of remotely sensed (Landsat) products and services in the domestic private sector. These businesses can then become targets for future NASA technology transfer efforts.

The identification of near- and far-term domestic business targets for Landsat technology was carried out in a three-stage market analysis, as illustrated in Figure 2-1. First, the total industry environment, i.e., the universe of industries to be considered, was identified. Second, all the industries in this environment were examined to identify those industries and, subsequently, those business types which require information potentially available by remote sensing means. These business types

FIGURE 2-1

METHODOLOGY OVERVIEW

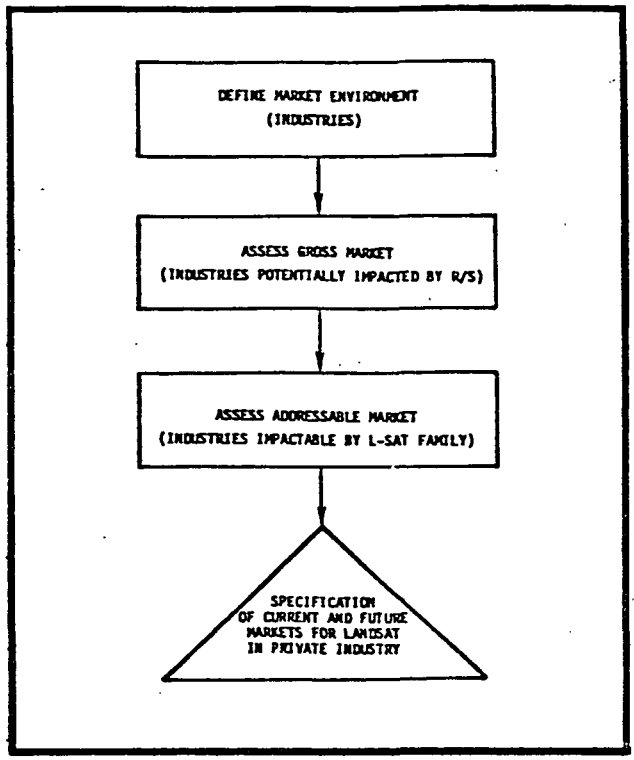


TABLE 2-1

MARKET ENVIRONMENT

INDUSTRY	SICC DIVISION
AGRICULTURE, FORESTRY, AND FISHING	A
MINING	B
CONSTRUCTION	C
MANUFACTURING	D
TRANSPORTATION, COMMUNICATIONS, ELECTRIC, GAS, AND SANITARY SERVICES	E
WHOLESALE TRADE	F
RETAIL TRADE	G
FINANCE, INSURANCE, AND REAL ESTATE	H
SELECTED SERVICES	I

constitute the gross market for Landsat. Finally, the potential Landsat market was identified by analyzing the information requirements of these business types and matching their requirements to current and projected Landsat capabilities, to identify those business types that could be served by Landsat.

2.3.1 MARKET ENVIRONMENT

The Standard Industrial Classification Code of U.S. industries was used to define the market environment. The Standard Industrial Classification (SIC) Code is a comprehensive multi-level partitioning of U.S. domestic industries into groups of similar function. The SIC is prepared by the Office of Management and Budget, Executive Office of the President. The SIC breaks down U.S. industries into five successively smaller levels of business aggregation. The highest level of aggregation is a Division. Smaller levels of aggregation are Major Group, Group, Industry, and finally, Business Type. There are nine major SIC industry divisions as shown in Table 2-1. These nine divisions represent over 200 individual industries which, in turn, represent well over 1000 individual business types.

2.3.2 GROSS MARKET

Definition of the gross market for Landsat requires the identification of businesses potentially impacted by remote sensing. Determination of the applicability of remote sensing in general and Landsat in particular to any particular business requires specific knowledge of the information needs for that business. Identification of the specific information requirements of the more than 1000 business types comprising U.S. domestic industry was beyond the scope of this effort. Therefore, a means of segregating the businesses potentially impacted by remotely sensed information was developed.

Remotely sensed information belongs to a broader class of information; that of spatial or geo-based information. Descriptions provided in the SIC Code Manual published by OMB give adequate information at each level of business aggregation so that the applicability of spatial information to each business segment can be judged. Therefore, the businesses requiring

significant amounts of spatial information were selected from the total industry environment for further analysis with regards to the applicability of remote sensing. This was done by determining the applicability of spatial information to business segments at each successive level of business aggregation. Segments not requiring spatial information and all successive levels of business aggregation related to those segments were dropped from consideration. This procedure is summarized in Figure 2-2.

As a result of this analysis procedure, six of the nine industry divisions were determined to require spatial information. Each of these six divisions were then broken down into their component major groups and the applicability of spatial information to each was determined. An example showing this breakdown and evaluation is illustrated in Figure 2-3 for one division; Division A, Agriculture Forestry and Fishing. Each of the major groups associated with Division A were determined to require spatial information. This process of breaking down industries requiring spatial information into their component elements at the next level of SIC aggregation, and subsequent evaluation of the applicability of spatial information to these components, is carried out at each successive SIC level until all the business types requiring spatial information are identified. As illustrated in the figure, four of the six business types associated with the Crop Planting, Cultivating and Protection industry require spatial information.

2.3.3 POTENTIAL MARKET FOR REMOTE SENSING AND LANDSAT

A profile was prepared for each business type requiring spatial information, identifying the applicability and relative potential value of remote sensing in general and Landsat in particular to each. Data on revenues and number of establishments were identified for each business type from data available from the U.S. Bureau of Census and the Internal Revenue Service. Each profile provides a description of the business type. Descriptions were derived from business descriptions provided in the SIC Code Manual and Bureau of Census documentation. Included in the profile is a breakdown of the major operational activities; i.e., those activities directly related to the production or provision of a marketable product or service. Then each of these operational activities was assigned a portion of the total

FIGURE 2-2

DEFINITION AND CHARACTERIZATION OF GROSS MARKET

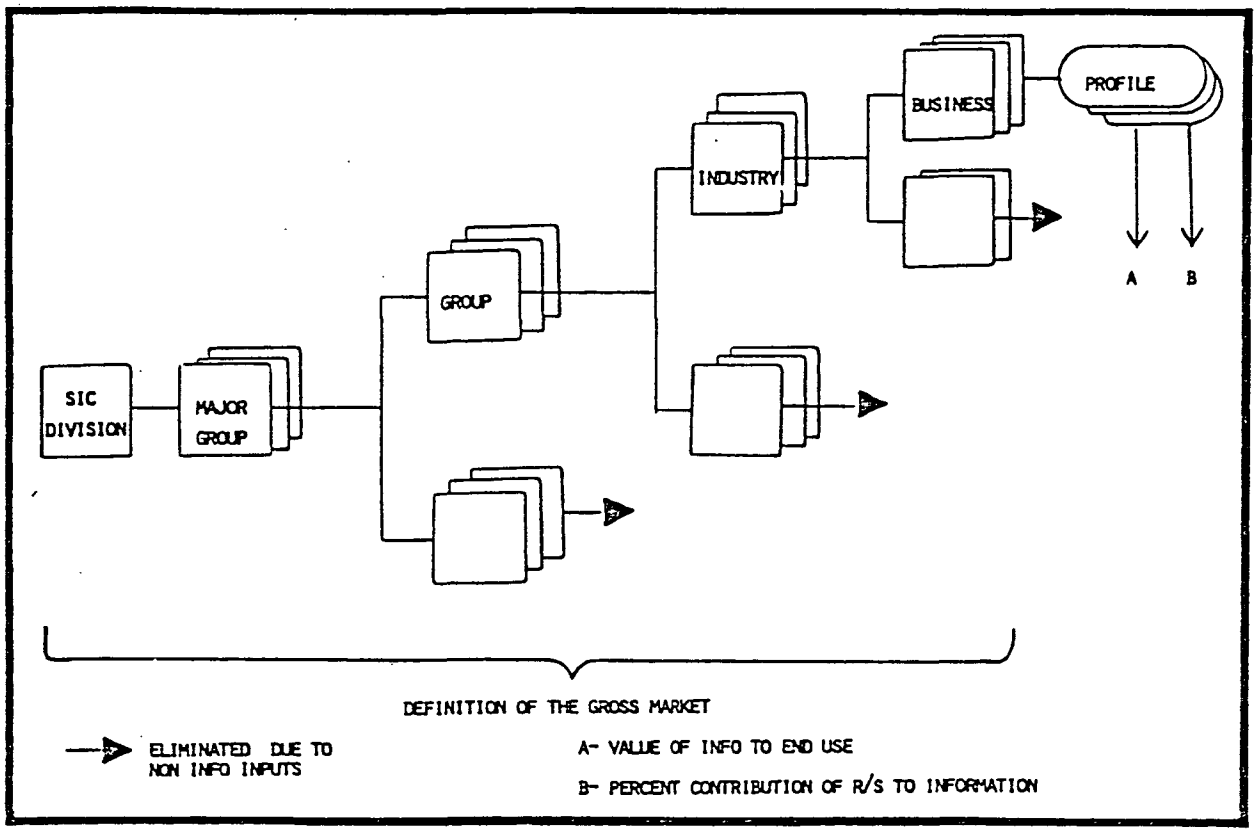
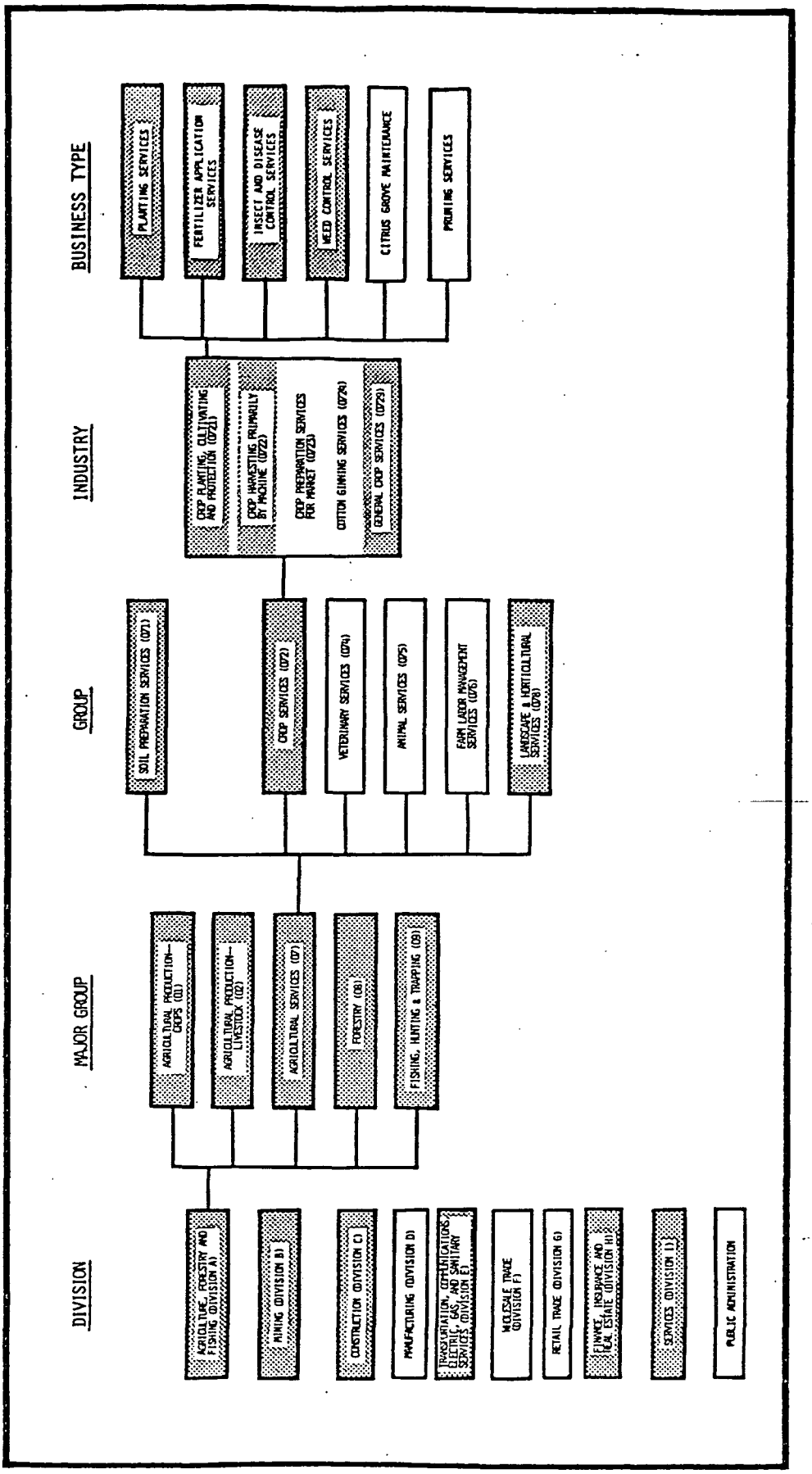


FIGURE 2-3

APPLICATION OF GROSS MARKET IDENTIFICATION METHODOLOGY



business revenue based upon its relative utilization of available business resources. This allocation of portions of the total business revenues to the various operational activities of that business will be used, in subsequent analysis, for weighting the relative impact of remote sensing and Landsat. (This factor is called the "Revenue Weighted Effect of Information" in Tables 4-1 and 4-2.) The operational activities and the proportion of total revenue that should be attributed to each were identified through a variety of sources: professional journals; professional societies; direct contact with business operators; trade associations; annual reports; and from a variety of professional and technical documents. This information is summarized on the first page of each profile as illustrated in Figure 2-4 for the business type, Crop Insect and Disease Control Services.

Successive pages of each profile serve to characterize the informational requirements of each of the operational activities. Each activity is analyzed to identify the models or outputs used which are related to spatial activities. The key information inputs required to support these models were identified and characterized by type, resolution and frequency. The applicability of remote sensing to the acquisition of the key information inputs was designated by listing the appropriate region of the electromagnetic spectrum used for detection of the information type. Three general regions of the spectrum (VIS, SWIR, TIR) were selected for consideration based upon their differing ability to discern surface information. A more detailed breakdown of the spectrum for use in identifying the various information types was beyond the scope of this study. VIS refers to the visible and near-infrared portion of the spectrum (0.4 to 1.0 micrometers). SWIR is the mid-infrared portion of the spectrum in the 1.0 to 3.0 micrometer range. TIR refers to the thermal infrared (8.0 to 13.0 micrometers).

The characterization of the information requirements of the Crop Insect and Disease Control business type is shown in Table 2-2.

A measure of the relative value to each business type of information available by remote sensing in general and Landsat in particular was determined from the profiles by a simple accounting process.

FIGURE 2-4

BUSINESS PROFILE

BUSINESS TYPE: Crop Insect and Disease Control Services

NUMBER OF ESTABLISHMENTS: 1,132

GROSS REVENUES: $328M

AVERAGE COMPANY REVENUES: $290K

DESCRIPTION: Crop Insect and Disease Control Service businesses are establishments engaged in aerial and/or on-ground dusting and spraying of crops for control of insects and disease. Cartographic information is required by these establishments for purposes of assessing control requirements, specifying application methods and scheduling application activities.

RELATIONSHIP OF THE MAJOR OPERATIONAL ACTIVITIES AND THE PERCENT OF REVENUE ATTRIBUTED TO EACH:

TABLE 2.2
BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING
Forecasting	Damage Prediction Warning	Crop Types	Field Size (≃50m)	Seasonal	VIS
		Soil Temperature	≃200m	2-10 days	TIR
		Soil Moisture	≃200m	2-10 days	TIR
		Topography	1:24,000 (6m)	1-2 years	VIS
		Egg Counts	—	Seasonal	NRS * (Sampling)
Assessment	Damage Locations and Severity	Crop Types	Field Size (≃50m)	Seasonal	VIS
		Crop Vigor	Sub-Field (≃10m)	2-10 days	SWIR (Sampling)
Planning	Integrated Pest Management Strategy	Crop Types	Field Size (≃50m)	Seasonal	VIS
	• Spray Compatibility	Crop Vigor	Sub-Field (≃10m)	2-10 days	SWIR
	• Application Windows				
	• Yield Improvements	Proximity of Environmentally Controlled Areas	1:24,000 (6m)	Yearly	VIS
	• Environmental Impact	Pest Types	---	Seasonal	NRS
		Pest Cycles	---	Seasonal	NRS
	• Flight Plan	Spray Costs	---	Seasonal	NRS
	• Timing	Weather	---	Daily	NRS
Application	Not Information Intensive				

*NRS - Not remote sensing

First, the portion of total business revenues assigned to activities whose successful completion is dependent upon the availability of spatial information is determined. For example, twenty percent of the revenues of the Crop Insect and Disease Control business type, whose profile was presented earlier, can be attributed to activities requiring spatial information as indicated in Figure 2-5.

Second, the revenue assigned to these spatial information intensive activities is apportioned equally to the information elements required by these activities. This equal proportionment is used based upon the assumption of equal relative value or importance of the various inputs required. A measurement of the relative value of information available by remote sensing means is then determined by aggregating the revenue assigned to these information elements. For example, if five out of ten of the information intensive activities are available by remote sensing means, then 50% of the revenues assigned to those information intensive activities is credited to remote sensing. (This factor is called "Revenue Weighted Effort of Remote Sensing" in Section 4).

The relative value of information available from Landsat is determined by first assessing which of the remotely sensible elements can be acquired from Landsat. This is done by comparing current and projected Landsat performance characteristics (Table 2-3) with the spectral, geometric and frequency requirements of the remotely sensible information inputs. The revenues assigned to those elements which can be provided by Landsat are aggregated to determine a measure of the relative "value" of information available from Landsat to each business. This process is summarized in Figure 2-6.

The relative value measure produced by this process, referred to in Section 4 as "Revenue Weighted Effect of Landsat," is a revenue weighted measure of the impact or effect which Landsat can potentially have upon business activities. This revenue weighting is necessary to make the potential impacts Landsat can have upon the activities of various businesses comparable in economic terms. The ability to compare the potential Landsat impacts on the various business types in economic terms is important to the selection of prospective technology transfer targets.

FIGURE 2-5

CROP INSECT AND DISEASE CONTROL SERVICES OPERATIONS

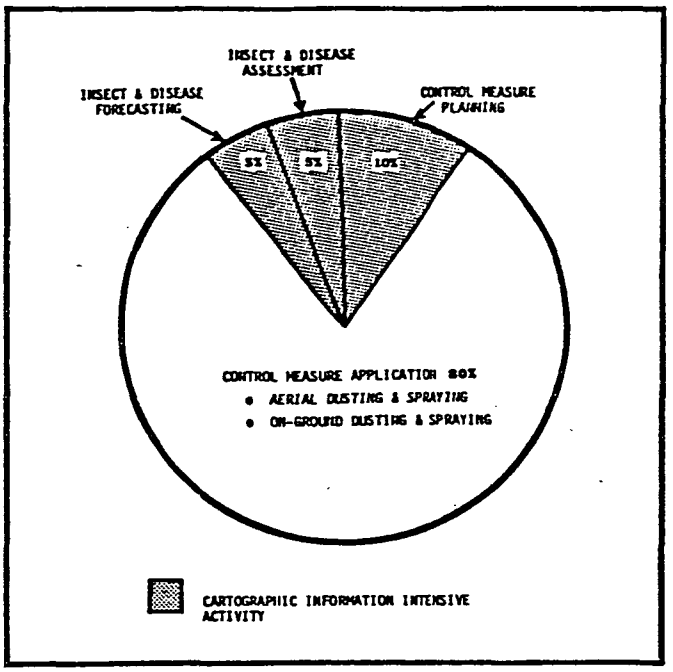


FIGURE 2-6

UTILITY OF BUSINESS PROFILES FOR DEFINING THE POTENTIAL MARKET

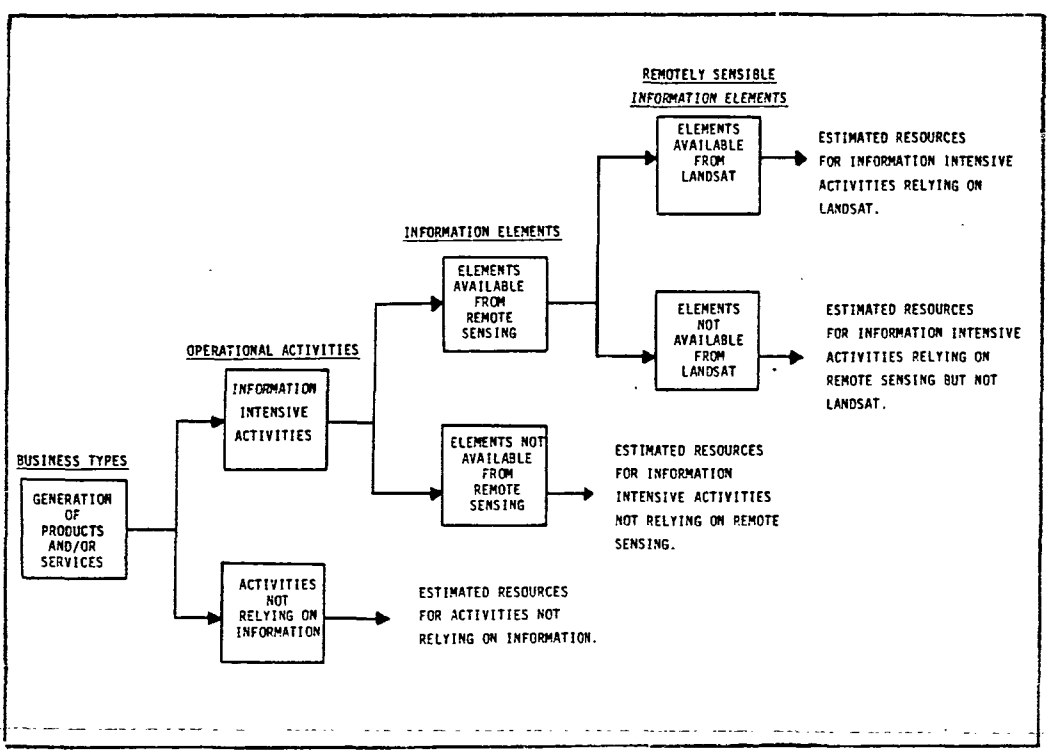


TABLE 2-3

REMOTE SENSING PLATFORM SENSOR CAPABILITIES

PLATFORM	TIME FRAME OF OPERATION	EFFECTIVE RESOLUTION (M)		
		VIS	SWIR	TIR
LANDSAT	TO 1982	80/45*	NA	240
TM	1982-1990	30	30	120
MLA (704 Km)	POST 1990	10	10	120
MLA (283 Km)	POST 1994	4	4	48

* The Agriculture, Forestry and Fishing, Division's business types were evaluated for the 1980 timeframe using an effective visible region ground resolution of 45 meters. The 45M effective resolution was computed based upon a sufficient RBV imagery backlog and processing capability for the RBV to serve a supplementary role for the MSS in satisfying near term imaging requirements. In a supplementary role field boundary information obtained from the RBV is overlayed on to MSS imagery to enhance the interpretation. The boundary information permits the elimination of radiometrically misleading MSS boundary pixels. The effectiveness of this multi-image overlay technique for increasing the effective resolution of the MSS has only been tested in agricultural areas. Consequently, for purposes of this study its use, admittedly optimistic, was applied to the business types in the agricultural business types only.

In dollar terms, the value measure produced by the above process can be thought of as a rough order of magnitude (ROM) estimate of the value of Landsat to a particular business type if all potential applications of Landsat were to be captured or realized. Caution should be used in applying this value measure outside the framework of this study, where it is used only as a tool for comparing the relative merit of Landsat to the various business types, because it is unrealistic to expect Landsat to capture all its potential applications. The fraction of applications which Landsat can or will capture is a function of many factors, not the least of which is the effectiveness of future technology transfer activities. For this reason, no attempt was made in this study to assess the capturable priviate industry market for Landsat. Instead, the approach taken in this report was to identify likely markets for Landsat and to assess guidelines for introducing Landsat into these markets.

2.4 METHODOLOGY FOR ANALYSIS OF THE FOREIGN MARKET FOR LANDSAT

The objective of this activity was to evaluate the degree to which remote sensing technology in general, and Landsat remote sensing technology in particular, can be utilized in the foreign market, and the extent that this can stimulate the domestic service industry in the foreign sector.

A case study/survey approach was used for this evaluation. Three case studies were selected for purposes of assessing the potential foreign sector market for Landsat products and services:

- The U.S. Agency for International Development (US/AID) remote sensing programs were examined to determine their potential for domestic private industry involvement in the foreign Landsat market.

- The activities of a foreign business which has become a supplier of Landsat-derived products and services in the foreign sector were examined.

- The foreign sector experiences of a domestic Landsat-derived product and service business were evaluated.

The potential for private industry involvement in the foreign Landsat market through participation in US/AID programs was evaluated through a survey and review of program documentation and discussions with an AID representative and a private sector participant.

The foreign business view of the foreign Landsat market was evaluated by a survey of the Landsat remote sensing experiences of an Italian based firm, ITALECO S.p.a. ITALECO has made significant investments over the past five to six years in developing a space remote sensing capability to support their architectural and engineering work.

The domestic business view of the foreign Landsat market was evaluated through a survey of the Landsat market experiences of ECOsystems International, Inc. This company is a small U.S.-based firm that has been actively marketing Landsat and related technologies in both the domestic and foreign arena over the past ten years.

3.0 THE SERVICE & MAPPING INDUSTRY FOR REMOTE SENSING PRODUCTS

3.0 THE SERVICE & MAPPING INDUSTRY FOR REMOTE SENSING PRODUCTS

3.1 INTRODUCTION

This section examines two segments of the private sector: the remote sensing service industry and the mapping industry. In Section 3.2 is a look at the experiences of several remote sensing service businesses, primarily those utilizing digital interpretation and analysis techniques. This examinaton will help the reader understand the current status of the remote sensing service industry as well as set the stage for future efforts toward greater private sector involvement in Landsat utilization. Section 3.3 examined the mapping industry in terms of its potential as a significant application of Landsat, or future satellite, technology.

3.2 SERVICE ORIENTED INDUSTRIES UTILIZING DIGITAL INTERPRETATION/ANALYSIS TECHNIQUES

Several companies have been studied, and personal interviews performed with the key individuals who have been involved the last 5 years in providing a service utilizing digital analysis/interpretation techniques. The review of this group of industries shows a few limited successes and several major failures. This review should provide NASA with some insight and guidance in involving these type industries in future Landsat technology transfer programs.

In studying these companies it is very apparent that NASA has some major obstacles to overcome before the private sector will commercially utilize Landsat technology in the immediate future. The industry has some negative attitudes about the Landsat program and the current techniques utilized by NASA in their technology transfer program. These are 1) the operational limitations of the Landsat system, 2) the neglect of the private sector in NASA Technology Transfer program, and 3) NASA's competition with the service industry sector in its current technology transfer programs.

Limitation of the Landsat System

The current difficulties in receiving reliable and timely data have frustrated many users in the private sector. Also, the uncertainties on future Landsat program has caused the private sector to delay investing in a program that has no certainty of continuing or providing a standardized data product in a reasonable time period. It appears that NASA Headquarters, with its technology transfer, is trying to "sell" the use of Landsat technology while at the same time Goddard Space Flight Center is operating its processing center as if Landsat data is for R&D only and therefore, does not have to comply with processing and disseminating data in a reasonable time frame. This situation is very confusing to the user sectors and is detrimental to the service industries ability to market Landsat technology.

Neglect of the Private Sector

As one spokesman for industry stated, "NASA has gotten just what their technology transfer program was designed to do - i.e., create a fragmented program involving state and local governments with almost total exclusion of private industry." The service industry is upset and frustrated with NASA and the Landsat program. One point of view is that if NASA had involved service industries a few years ago, when it had both large and small industries involved, that today there would be a viable industry providing an analysis service to all sectors. These industries now would be working with NASA to provide a transfer of technology throughout the entire community. With a partnership between NASA and industry in the late 1970's the technology program would have been better able to overcome Landsat's operational problems.

Competition with Service Industries

The digital analysis industry has fallen upon hard times in the last few years trying to compete for primarily small, isolated contracts. In addition, the private sector perceives that NASA has compounded the problem by essentially competing with industry by providing service through technology transfer to various users, some of which might otherwise have contracted with the service industries. As a result, most of the

larger companies either have gotten out of the business or have cut back their operation in the digital analysis services because they feel the market is too diffuse to stay actively in the business. For example, one representative said, "it takes too much marketing effort (money) to keep a steady flow of $10K contracts coming in."

Today in the digital analysis service industry the Environmental Research Institute of Michigan (ERIM) is the largest most successful company (approximately $2.5 million per year) providing services. General Electric, ESL, and EARTHSAT have reduced their capabilities in recent years and provide a limited service at this time. Lockheed and Bendix have sold off their analysis systems and no longer provide this service.

Case History

ERIM has been able to maintain a reasonable level of business by supporting primarily oil companies, foreign (AID contracts), and DOD. They are growing in the international market, using AID contracts and their spin-offs, and the ERIM International Symposiums. ERIM feels these two mechanisms make it possible for them to survive - a service company would have problems marketing in the foreign arena without these contacts. However, because there are so many parts of the world for which there are no map data, ERIM and a few other companies are concentrating on the foreign market. ERIM has developed a line of products which includes geo-corrected images registered to a map base. In addition, ERIM is finding a new source of business with oil companies, who have previously used primarily imagery interpretation, and are now exploring the use of computer analysis for extrapolating more detailed geologic data from Landsat.

SUMMARY:

The Landsat program is presently in such a poor state of affairs that it will be very difficult to revitalize the data analysis service industries in the near future. There are a limited number of companies remaining and, with the exception of ERIM, most are fairly small firms that provide specialized service to a very small domestic market, aside from the oil industries. Thus, for these service companies to survive they are devoting their marketing efforts to the foreign arena.

3.3 POTENTIAL FOR THE USE OF LANDSAT IN THE MAPPING INDUSTRY

The private mapping industry has significant potential for utilization of remote sensing technology. Unfortunately, Landsat-derived information does not play a significant role in the mapping industry, largely as a consequence of Landsat's relatively gross resolution. However, increasing demand for new map types, such as the trend toward digital map products, coupled with expected improvement in spectral and spatial resolution provided by future satellite systems, should change this level of impact.

This section presents an examination of the potential present and future role of Landsat-derived information in the mapping industry. This examination is useful in assessing the opportunities available to the Landsat service industry. The following information provides inputs to this assessment:

- The types and volume of maps currently being produced by the national mapping industry;
- The estimated demand for each map type through the 1990's;
- The role of remote sensing in the production of each map type;
- The potential contribution of existing and planned Landsat-type platforms, and;
- The fraction of national mapping activities attributable to private industry.

3.3.1 MAPPING INDUSTRY OVERVIEW

The government and private activities which make up the national mapping industry are characterized by the following:

- The expenditures for mapping activities totaled approximately $890 million in 1979.

- o Federal agencies are responsible for the major portion (approximately 84% of the total funding. Included in the 84% is approximately 5% of matching funds from states and local governments.

- o Federal agencies contract approximately 50% of their effort to private aerial survey, interpretation, and graphic art companies.

- o State and Local Governments perform 5% (by dollar value) of the mapping effort. Approximately 60% of the state and local effort is accomplished through contracting to private firms.

- o The private sector is responsible for the remaining approximately 11% of the total dollar value either for their own use or to support requirements of other commercial firms.

- o Government is, therefore, the major customer, accounting for 89% of the expenditures; however, the private sector directly or indirectly receives up to 56% of the funding.

The cost allocation between the "raw" products and the end-product is of significance to the private mapping market. From Table 3-1, it can be seen that the cost of gathering the raw products is typically on the order of 5% of total costs; whereas the added value of interpretation and cartography accounts for 65%. Another 11% goes for printing costs; with 16% for distribution expenses.

It is worth noting that, in addition to the mapping activities indicated above, there are other activities aimed at providing remotely sensed products. Typical of these is the Agricultural Stabilization and Conservation Service (ASCS) which annually contracts for some 1,300,000 square kilometers worth of aerial photos. These are contracted to commercial private enterprises for approximately $1.7 million yearly (1978 figure). They are available to the general public after serving their initial ASCS purpose.

TABLE 3-1

BREAKDOWN OF COSTS BY ACTIVITIES IN THE END-TO-END PRODUCT CHAIN OF FEDERAL CIVIL MAPPING

ACTIVITY	PERCENT OF TOTAL (COST)
Data Collection	5
Interpretation	21
Cartography	44
Printing	11
Distribution	5
Archiving and Sales	11
Research and Development	3
TOTAL	100

As indicated by the funding, the mapping industry is dominated by activities of federal, state and local government programs. For example, the U.S. Geological Survey (USGS) provides the majority of the base-maps for most federal, state and local mapping activities. The USGS activities are funded both directly through their own budget and by transfer payments from outside agencies. Where standard USGS products are not available, the other agencies either fund special USGS programs or perform their own specialized surveys.

Table 3-2 shows the volume of maps produced under funding from the principal Federal agencies in FY 1979. These figures were compiled from agency publications and interviews with personnel from the responsible agencies. Seven federal agencies produce the bulk of the maps for the U.S. They are led by the USGS which accounts for 71% of the federal mapping activity. Included is the contribution of USGS to the other Federal agencies in cooperative programs and through preparation of base maps.

Recent trends in mapping activity can be used to project map production over the next 15 years. Production trends specified in USGS Budget Justifications for the years 1977 to 1981 (reference 7, Table 3-10) were used to

TABLE 3-2

1979 MAP PRODUCTION BY FEDERAL/STATE AGENCIES

MAP TYPE	MAP SCALE / PRODUCER	1:15,000,000	1:11,000,000	1:8,000,000	1:7,500,000	1:3,168,000	1:2,500,000	1:1,000,000	1:500,000	1:250,000	1:150,000	1:125,000	1:100,000	1:63,360	1:62,500	1:50,000	1:31,680	1:30,000	1:25,000	1:24,000	1:20,000	1:15,840	TOTAL	REFERENCES*
TOPOGRAPHIC	USGS/DMA							60		90			150							2700			3000	8 9
BOUNDARY	USGS							44	7							49							100	9
CADASTRAL	USGS/BLM																			27			27	9
CENSUS	BUREAU CENSUS													2360						2640	4000		8000	10
FEDERAL PROPERTY	USGS															5				5			10	9
ORTHOPHOTOMAPS	USGS																		27	508			535	9
LANDUSE	USGS									4			6										10	9
NAUTICAL CHARTS	NOAA/DMA								314		827										512		1653	6 12 11
BATHYMETRIC CHARTS	NOAA/DMA							17		347						347					116		827	12 11
TOPOGRAPHIC--BATHYMETRIC	NOAA/USGS																			25			25	9
FLOOD PLAIN	USGS																			50			50	9
WATER RESOURCES	USGS									3					2	8				40			53	9
CLIMATIC	NOAA	51	51	210	45		210																567	13
GEOLOGIC HAZARD	USGS															1				1			2	9
GEOLOGIC	USGS								4	11			45							47			107	9
MINERAL RESOURCE	USGS									5				16						247			268	9
SOILS	USDA																1			26	68	41	136	14
CLINOMETRIC	USGS															4				4			8	9
SNOW COVER	NOAA/COE	56			352		304									88							800	15
AERONAUTICAL	NOAA					48	48						95			95		4479					4765	6
ROAD	DOT/STATES											1188		1188						10824			13200	17
RECREATION	USGS															3							3	9
TOTAL		107	51	210	397	48	562	121	325	460	827	1188	296	2564	2	600	1	4479	27	17144	4696	41	34146	

*See Table 3-10

make these projections. These trends indicate an increase in large scale (1:15,840-1:31,680) mapping of about 1.5% per year. (Large scale maps accounted for 77% of all map production in 1979). Small scale (1:250,000-1:15,000,000) mapping is also increasing at an effective rate of 7% per year. Intermediate scale production is declining at a rate of 8% per year. Table 3-3 shows the projected distribution of map production by type and scale for 1995 by applying this trend information to current production.

3.3.2 Role of Remote Sensing in Civil Land Mapping

Each type of map requires a different set of information inputs in its production. A portion of this information is potentially available from remote sensing and the balance is derived from non-remote sensing sources.

The applicability of remote sensing to the production of each map type was evaluated in a three step process. First, the principal information elements required for production of each map type were identified from agency specifications (reference 1 and 3, Table 3-10). Second, the information elements were segregated into remotely sensed and non-remotely sensed categories (reference 4, Table 3-10). Third, the applicable remote sensing band options (VIS, SWIR, and TIR, as defined in section 2.3.3) were evaluated for each remotely sensed information category (reference 18 through 22, Table 3-10).

The remotely sensed data information classes for each map type were separated according to six categories as shown in Table 3-4. The elements in each category represent aggregation at levels of similar function, e.g., the category-inland water features includes streams, lakes, ponds, etc. The major difference between each with regard to remote sensing is the spatial resolution required to discern it. Table 3-4 also relates the band options and the remotely sensed information inputs for each map type. The relationship of the band options to the map types were derived from a direct analysis of the sources indicated in the footnotes to Table 3-4.

Table 3-5 lists the non-remote sensing information required for each type of map. The information elements were aggregated at the same level used in the remote sensing information. The relationship between the information

TABLE 3-3

ESTIMATED MAP PRODUCTION: 1995

MAP TYPE	PRODUCER / MAP SCALE	1:15,000,000	1:11,000,000	1:8,000,000	1:7,500,000	1:3,168,000	1:2,500,300	1:1,000,000	1:500,000	1:250,000	1:150,000	1:125,000	1:100,000	1:63,360	1:62,500	1:50,000	1:31,680	1:30,000	1:25,000	1:24,000	1:20,000	1:15,840	1979 ANNUAL PRODUCTION VOLUME
TOPOGRAPHIC	USGS/DMA							168		252			45							3510			3975
BOUNDARY	USGS							123	20							15							158
CADASTRAL	USGS/BLM																			35			35
CENSUS	BUREAU CENSUS													408						3432	5200		9040
FEDERAL PROPERTY	USGS															2				7			9
ORTHOPHOTOMAPS	USGS																		35	660			695
LANDUSE	USGS									11			2										13
NAUTICAL CHARTS	NOAA/DMA								879		2316										666		3861
BATHYMETRIC CHARTS	NOAA/DMA							48		972						104					151		1275
TOPOGRAPHIC--BATHYMETRIC	NOAA/USGS																			33			33
FLOOD PLAIN	USGS																			65			65
WATER RESOURCES	USGS									8					1	2				52			63
CLIMATIC	NOAA	142	142	588	126		588																1586
GEOLOGIC HAZARD	USGS															1				1			2
GEOLOGIC	USGS								11	31			14							61			117
MINERAL RESOURCE	USGS									14				5						321			340
SOILS	USDA																1			34	88	53	176
CLINOMETRIC	USGS															1				5			6
SNOW COVER	NOAA/COE	157			986		851									26							2020
AERONAUTICAL	NOAA					134	134						29			29		5823					6149
ROAD	DOT/STATES											356		356						14071			14783
RECREATION	USGS															1							1
TOTAL		299	142	588	1112	134	1573	339	910	1288	2316	356	90	769	1	181	1	5823	35	22287	6105	53	44402

TABLE 3-4

POTENTIAL REMOTE SENSING INFORMATION

INPUTS TO THE PRINCIPAL MAP TYPES

SENSOR REQUIREMENTS				REMOTELY SENSIBLE MAP INFORMATION	MAP TYPE																						
VISIBLE	VISIBLE/SWIR	VISIBLE/SWIR/TIR	SOURCE		TOPOGRAPHIC	BOUNDARY	CADASTRAL	CENSUS	FEDERAL PROPERTY	ORTHOPHOTOMAPS	LANDUSE	NAUTICAL CHARTS	BATHYMETRIC CHARTS	TOPOGRAPHIC-BATHYMETRIC	FLOOD PLAIN	WATER RESOURCES	CLIMATIC	GEOLOGIC HAZARD	GEOLOGIC	MINERAL/RESOURCE	SOILS	CLINOMETRIC	SNOWCOVER	AERONAUTICAL CHARTS	ROAD	RECREATION
				TERRAIN FEATURES																						
X			1	SURFACE RELIEF FEATURES	X									X	X			X	X			X	X	X		X
X			1	INLAND WATER FEATURES	X	X	X	X	X		X	X		X	X	X		X	X		X	X	X	X	X	X
X			2	COASTAL FEATURES	X	X	X	X	X		X	X	X	X	X			X	X		X	X	X	X	X	X
X			2	ROADS/TRAILS/RAILROADS/RUNWAYS	X	X	X	X	X		X			X	X			X						X	X	X
X			2	BUILDINGS/STRUCTURES			X	X	X			X			X			X						X	X	X
X			1	VEGETATION	X									X												X
		X	5	SURFACE COMPOSITION (SOIL/ROCK/ OTHER)														X	X		X					
X			2	LINEAR FEATURES			X	X											X							
				HYDROLOGIC FEATURES																						
X			1	DRAINAGE PATTERNS											X	X							X			
		X	1	BATHYMETRY AND RELATED FEATURES								X	X	X		X										
		X	1	WATER QUALITY												X										
			1	WATER LEVELS								X	X	X	X											
		X	1	CURRENTS								X														
				GEOLOGIC FEATURES																						
		X	1	ROCK TYPE																X	X					
		X	2	AREAS OF MINERALIZATION																	X					
		X	1	GEOTHERMAL AREAS															X	X						
X			2	LAND FORMS															X	X				X		X
X			1	GEOLOGIC STRUCTURE														X	X	X						
		X	2	SOIL TYPE																	X					
				LANDUSE																						
X			1	URBAN LAND CLASS				X			X															
X			1	BARREN LAND CLASS				X			X															
	X		4	WETLAND CLASS							X															
X			1	TUNDRA							X															
X			1	FOREST TYPE				X	X		X															
X			1	AGRICULTURAL LAND CLASS				X			X															
X			1	CROP TYPE				X																		
	X		4	AREAS OF IRRIGATION				X																		
	X		4	WILDLIFE HABITATS					X																	

TABLE 3-4 (cont.)

POTENTIAL REMOTE SENSING INFORMATION

INPUTS TO THE PRINCIPAL MAP TYPES

SENSOR REQUIREMENTS			SOURCE	REMOTELY SENSIBLE MAP INFORMATION	MAP TYPE																						
VISIBLE	VISIBLE/SWIR	VISIBLE/SWIR/TIR			TOPOGRAPHIC	BOUNDARY	CADASTRAL	CENSUS	FEDERAL PROPERTY	ORTHOPHOTOMAPS	LANDUSE	NAUTICAL CHARTS	BATHYMETRIC CHARTS	TOPOGRAPHIC-BATHYMETRIC	FLOOD PLAIN	WATER RESOURCES	CLIMATIC	GEOLOGIC HAZARD	GEOLOGIC	MINERAL/RESOURCE	SOILS	CLINOMETRIC	SNOWCOVER	AERONAUTICAL CHARTS	ROAD	RECREATION
				CLIMATIC/WEATHER																							
		X	2	SURFACE TEMPERATURE													X										
		X	2	SOIL MOISTURE													X										
	X		3	CLOUD COVER													X										
	X		3	SNOW OR ICE													X						X				
				IMAGERY																							
X			2	VISIBLE							X																
X			2	NEAR INFRARED							X																

1. NOAA User Survey
2. Manual of Remote Sensing, American Society of Photogrametry, 1975.
3. GSFC MLA Presentation, 1980
4. OERS-TIME, ECOsystems, 1979
5. Handbook of Military Infrared Technology, Office of Naval Research, 1965.

TABLE 3-5

NON-REMOTE SENSING INFORMATION REQUIRED IN THE PRODUCTION OF THE PRINCIPAL MAP TYPES

NON-REMOTE SENSING MAPPING ELEMENTS	MAP TYPE																				
	TOPOGRAPHIC	BOUNDARY	CADASTRAL	CENSUS	FEDERAL PROPERTY	ORTHOPHOTOMAPS	LANDUSE	NAUTICAL CHARTS	BATHYMETRIC CHARTS	TOPOGRAPHIC-BATHYMETRIC	FLOOD PLAIN	WATER RESOURCES	CLIMATIC	GEOLOGIC HAZARD	GEOLOGIC	MINERAL/RESOURCE	SOILS	CLINOMETRIC	SNOW COVER	AERONAUTICAL	ROAD	RECREATION
INLAND WATER & RELATED FEATURE ID	X	X	X	X	X	X	X			X	X	X		X	X		X	X	X	X	X	X
COASTAL FEATURE ID	X	X	X	X	X	X	X	X	X	X	X			X	X		X	X	X	X	X	X
TRANSPORTATION FEATURE ID	X	X	X	X	X	X	X			X	X			X						X	X	X
BUILDING & URBAN FEATURE ID	X		X	X	X	X				X	X			X						X	X	X
PUBLIC-USE BUILDINGS	X		X	X	X	X				X												X
SPECIAL PURPOSE AREAS	X		X	X	X	X	X			X	X			X			X				X	X
UNDERGROUND MINES	X		X	X	X	X				X				X	X							
CIVIL BOUNDARIES		X		X	X		X						X								X	
PUBLIC LAND SUBDIVISIONS		X		X			X															
PLACE & MISCELLANEOUS FEATURE ID	X		X	X	X	X		X		X	X		X	X	X	X	X	X	X	X	X	X
PLACE & FEATURE OWNERSHIP			X		X			X														
STRATIGRAPHIC INFORMATION														X	X	X	X					
LOCATION OF ENVIRONMENTAL MONITORING STATIONS											X	X		X								
GROUND WATER INFORMATION												X										
RADIO SOURCE/POSITION INFORMATION								X												X		
RESTRICTED AREAS					X			X												X		X
FLIGHT PATH & AERIAL APPROACH INFORMATION																				X		
AIRCRAFT FLIGHT ROUTE INFORMATION																				X		
GEODETIC CONTROL POINTS	X								X	X				X	X							
SOIL PROPERTY DATA																	X					
POPULATION DENSITY				X							X			X								
CULTURAL POPULATION DISTRIBUTION DATA				X																		
HOUSING DATA				X																		
TIDES								X														
DEEP WATER BATHYMETRY									X	X												
NAVIGATION/REGULATED AREAS								X												X		X
PROTECTED AREAS					X			X														
HUMIDITY													X									
AIR PRESSURE													X									

elements and the map types were derived from an analysis of the sources footnoted in Table 3-4.

Even though the "cost" of obtaining each information element varies, there is no direct, available data to assess their relative weight. For the purposes of this effort, each informational elements was assumed to have equal weight with regards to the map's production.

The equal weight assumption was used to assess the contribution of each band option in the production of each map type, i.e., if one of the band options can provide 7 of the 10 information elements required for the production of a particular map, that option's potential contribution is 70%.

The contribution of each band option to each map type was multiplied by the estimated production volumes of each map type to obtain the "equivalent number of maps" potentially provided by each band option. The hypothesis here is that remote sensing inputs to different map types can be aggregated to produce equivalent map units.

This technique is a method to assess the potential impact remote sensing can have on the mapping industry. It is recongized that this is only an approximation, since different map types require different levels of total effort and the number of specific information elements is not constant. However, since data for relative cost of each map type are not available, it is a reasonable rough order of magnitude (ROM) approach.

The applicability of remote sensing was further evaluated by assessing the sensor ground resolution required to support the production of maps at various scales. The resolution required by each map scale was derived by consideration of technical standards adopted by the U.S. mapping industry.

Technical standards adopted by the US Mapping Industry (reference 1, Table 3-10) dictate that the accuracy of a map is ½mm at all scales. Application of information theory dictates that to obtain reliable accuracies at a stated limit, measurement accuracies must be at least ½ of that limit, i.e., ½mm accuracy requires measurements within ¼mm.

The effective resolution required of the sensor system as a function of map scale is therefore:

$$\text{Resolution} = \frac{SF}{4000} \text{ (meters)}$$

where: SF = Scale Factor = 1/map scale

For example, for a map scale of 1/100,000, the ground resolution required is:

$$R = \frac{100,000}{4,000} = 25 \text{ meters}$$

Table 3-6 relates ground resolution to map scale for the range of resolutions postulated as being potentially available from the Landsat family of satellites. A sensor must provide resolution equal to or better than those given in the table in order to provide information at the indicated scales.

3.3.3 POTENTIAL CONTRIBUTION OF REMOTE SENSING IN THE MAPPING INDUSTRY

The equivalent number of maps which can potentially be satisfied by the Landsat family of satellites was determined by first relating the spectral bands provided by current and postulated Landsat-type platforms to the map information requirements. Secondly, the resolutions provided by current and postulated Landsat family of satellites (shown in Table 3-7) were related to the map applicable resolutions determined by map scale. This two step assessment is summarized in Table 3-8.

Table 3-8 shows that the number of equivalent maps on which Landsat can have an impact in the 1980-1981 time frame is about 800 equivalent maps. This indicates that the current Landsat system can effectively satisfy less than three precent of the total mapping industry requirements. The Table also shows that only minimal increases can be expected from the introduction of the thematic mapper and standard orbit (704 km) MLA. Not until 1995, when a low orbit MLA is under consideration, does the Landsat family of satellites show significant potential for addressing the information requirements of the national mapping industry. The equivalent number of maps affected by satellite-derived information for this time

TABLE 3-6

RELATIONSHIP BETWEEN SENSOR GROUND RESOLUTION REQUIRED AND MAP SCALE

SCALE	REQUIRED RESOLUTION (M)
1: 1,000,000 and smaller	250
1: 500,000	125
1: 250,000	63
1: 150,000	38
1: 125,000	31
1: 100,000	25
1: 63,360	16
1: 62,500	15
1: 50,000	13
1: 31,680	8
1: 30,000	7
1: 24,000	6
1: 20,000	5
1: 15,840	4

TABLE 3-7

REMOTE SENSING PLATFORM SENSOR CAPABILITIES

PLATFORM	TIME FRAME OF OPERATION	EFFECTIVE RESOLUTION (M)		
		VIS	SWIR	TIR
LANDSAT	TO 1982	80/45*	NA	240
TM	1982-1990	30	30	120
MLA (704 Km)	POST 1990	10	10	120
MLA (283 Km)	POST 1994	4	4	48

*This resolution is based upon the combination of Landsat MSS and RBV data. See Table 2-3 for further discussion.

TABLE 3-8

PROJECTION OF THE YEARLY NUMBER OF EQUIVALENT MAPS SERVED BY LANDSAT-TYPE REMOTE SENSING

YEAR	SENSOR TYPES PLATFORM	EQUIVALENT NO. OF MAPS			TOTAL
		VIS	SWIR	TIR	
1980	MSS & TIR	578	--	215	793
1982	TM	1427	269	230	1926
1984	TM	1526	308	263	2097
1986	TM	1655	353	302	2310
1988	TM	1818	404	345	2567
1990	MLA (704 Km)	2584	491	395	3470
1992	MLA (704 Km)	2733	554	453	3740
1994	MLA (283 Km)	14696	954	683	16333

frame represents approximately 35% of the total mapping industry information requirements. However, it is unlikely that this low orbit option will become a reality, due to technical limitations of such a configuration. The low orbit MLA option is presented here, only as an example of the high level of performance (4-6 meter ground resolution) which must be achieved in order to have potential significant impact upon the mapping industry.

Until this level of performance is achieved Landsat data will not constitute a primary source for map information. Its role for the foreseeable future will be limited to monitoring gross landcover changes and assisting in the selection process for updating maps.

An upper bound estimate of the annual monetary value of the Landsat family of satellites to the private mapping industry was obtained by the following rationale:

- The current expenditure for mapping is $890 M (1980 $).
- This translates to expenditures of approximately $6,800 per map for data collection and interpretation.
- Multiplying this amount times the equivalent number of maps served by projected future sensors yields a measure of the potential "value" of Landsat-type remote sensing to national mapping.
- Multiplying values thus obtained by 56%, the fraction of expenditures directly or indirectly received by the private business sector, yields an approximation of the dollar amount available to the Landsat-type remote sensing service industry.

Table 3-9 presents the projections of the dollar amount of Landsat-type remote sensing business opportunity in the private mapping industry. The table shows that the dollar amount available to the remote sensing service industry is expected to rise approximately $10M dollars over the period 1980-1992, from a low of $4M to $14M. A more dramatic increase of almost $50M is postulated over the much shorter 1992-1994 time period, based upon the dubious assumption of a low orbit MLA. This increase would bring the total amount to $62M.

TABLE 3-9

PROJECTION OF THE YEARLY VALUE OF LANDSAT-TYPE REMOTE SENSING TO THE PRIVATE MAPPING BUSINESS

YEAR	SENSOR TYPES	VALUE ($ M)
1980	LSAT, MSS & TIR	4
1982	TM	7
1984	TM	8
1986	TM	9
1988	TM	10
1990	MLA	13
1992	MLA	14
1994	MLA	62

TABLE 3-10

REFERENCES FOR MAPPING STUDY

1. "Report of the Federal Mapping Task Force on Mapping, Charting, Geodesy and Surveying, July 1973," Executive Office of the President, Office of Management and Budget.

2. Thompson, M.M., Maps for America, USGS, 1979.

3. United States Geological Survey Yearbook, Fiscal Year 1979.

4. "Remote Sensor Image Capabilities for Acquisition of Terrain Information," U.S. Army Engineer Topographic Laboratories, Fort Belvoir, VA. June 1976.

5. Experimental results obtained by ECOsystems using LANDSAT MSS and RBV data and aerial photos in foreign countries.

6. National Oceanic and Atmospheric Administration Budget Justification, F.Y. 1979.

7. U.S. Department of the Interior Budget Justification, F.Y. 1977 through F.Y. 1981.

8. 1979 United States Geological Survey Yearbook Supplementary Appendix.

9. United States Geological Survey Annual Production Report amended by conversation with Mr. Bruce Rice of the Map Sales Division.

10. Personal communication with Mr. Robert Marx, Chief Geography Division, Bureau of Census.

11. Personal communication with Mr. DeYoung, Navigation Department, Defense Mapping Agency.

12. Personal communication with Mr. Bert Thompson, Ocean Services Division of NOAA.

13. Personal communication with the Public Affairs Office of NOAA.

14. Personal communication with Mr. Gockowski of the Soil Conservation Service Division of the United States Department of Agriculture.

15. Personal communication with Mr. Stan Schneider of the National Environmental Satellite Service Division of NOAA.

16. Marx, R., Data Access Description--Census Geography, U.S. Bureau of Census, 1979.

17. Personal communication with Mr. Shingler and Mr. Ed Poland of the Federal Highway Administration.

TABLE 3-10 (cont.)

REFERENCES FOR MAPPING STUDY

18. NOAA-ORES User Survey

19. Manual of Remote Sensing, American Society of Photogrametry, 1975.

20. Rango, A., Operational Applications of Satellite Snowcover Observations, 1979.

21. OERS-TIME, ECOsystems, 1979.

22. Handbook of Military Infrared Technology, Office of Naval Research, 1965.

While the dollar values shown should be recognized as only rough order of magnitude estimates, they do reflect the importance of the technical characteristics of satellite data in determining its utility to the private mapping industry. The increasingly important market for large scale maps, Landsat-type remote sensing products must be technically advanced, particularly with regards to resolution.

4.0 IDENTIFICATION OF THE PRIVATE SECTOR USERS

4.0 IDENTIFICATION OF THE PRIVATE SECTOR USERS

4.1 INTRODUCTION

The Standard Industrial Classification was the mechanism used in this study to segment the various private economic activities into a workable format. This division of the industries in the private sector allowed further detailed analysis to be performed and a classification to be developed that allowed economic and informational data to be studied down to individual business types and establishments. From this detailed classification the individual business types were identified which could potentially use remote sensing/Landsat derived information.

4.2 INDUSTRIAL DIVISIONS AND BUSINESS TYPES SELECTED FOR STUDY

The following describes the business activities of the major industrial divisions studied. The industry/business types selected for detailed analysis and for which business profiles were prepared are listed under each major industry division description.

4.2.1 AGRICULTURE, FORESTRY, AND FISHING

This division includes establishments primarily engaged in agricultural production, forestry, commercial fishing, hunting and trapping, and related services.

The classification of agricultural production covers establishments (farms, ranches, dairies, greenhouses, nurseries, orchards, hatcheries, etc.) primarily engaged in the production of crops, plants, vines, or trees (excluding forestry operations); and the keeping, grazing, or feeding of livestock for the sale of livestock or livestock products, for livestock increase, or for value increase. Livestock as used here includes cattle, sheep, goats, hogs, and poultry. Also included are animal specialties such as horses, rabbits, bees, pets, fur-bearing animals in captivity and fish in captivity. Agricultural production also includes establishments primarily engaged in the operation of sod forms, mushroom

cellars, cranberry bogs, poultry hatcheries, and in the production of bulbs, flower seeds, and vegetable seeds.

Farms are the establishment units generally utilized for the purpose of industrial classificatin of agricultural production. A farm may consist of a single tract of land, or a number of separate tracts which may be held under different tenures.

The classification of agricultural services includes establishments primarily engaged in supplying soil preparation services, crop services, landscape and horticultural services, veterinary and other animal servies, and farm labor and management services.

The classification of forestry covers establishments primarily engaged in the operation of timber tracts, tree farms, forest nurseries, the gathering of forest products, or in performing forestry services. Logging camps and logging contractors are not classified in this division.

The classification of fishing, hunting, and trapping covers establishments primarily engaged in commercial fishing (including shellfish and marine products); operating fish hatcheries, and fish and game preserves; and commercial hunting and trapping.

From this division, detailed business profiles were prepared on the following Industries/Business types:

Agricultural Production (Crops)

- o Field Crop Farms
- o Vine and Tree Crop Farms

Agricultural Production (Livestock)

- o Livestock Farms/Ranches

Soil Preparation Services

- o Plowing and Seed Bed Preparation
- o Fertilizer Application and Other Chemical Treatment of Soil

Crop Planting, Cultivating and Protection Services

- o Planting Services
- o Fertilizer Application Services (after planting)
- o Weed Control Services (after planting)
- o Crop Insect and Disease Control Services

Harvesting Services

- o Harvesting Services

Landscaping Counseling and Planning

- o Landscape Architects

Forestry Services

- o Forest Farms
- o Forestry Services

Hunting, Trapping and Game Propagation

- o Wildlife Management

Commercial Fishing

- o Catching of Finfish

4.2.2 MINING

This division includes all establishments primarily engaged in mining. Mining is here used in the broad sense to include the extraction of minerals occurring naturally: solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. The term "mining" is also used in the broad sense to include quarrying, well operation, milling (crushing, screening, washing, flotation, etc.), and other preparation customarily done at the mine site, or as a part of mining activity.

Exploration and development of mineral properties are included. Services performed on a contract, fee, or similar basis in the development or operation of mineral properties are classified separately but within this

division. Establishments which have complete responsibility for operating mines, quarries, or oil and gas wells for others on a contract, fee, or similar basis are classified according to the product mined rather than as mineral services.

From this division, detailed business profiles were prepared on the following Industries/Business types:

Metal Mining

- o Iron Ores
- o Copper Ores
- o Metal Mining Services

Bituminous Coal and Lignite Mining

- o Bituminous Coal and Lignite
- o Bituminous Coal and Lignite Mining Services

Oil and Gas Extraction

- o Crude Petroleum and Natural Gas
- o Drilling Oil and Gas Wells
- o Oil and Gas Exploration Services

Mining and Quarrying of Nonmetallic Minerals, Except Fuels

- o Crushed and Broken Stone
- o Sand and Gravel
- o Nonmetallic Minerals (except fuels) Services

4.2.3 CONSTRUCTION

This division includes establishments (or kind-of-activity units) primarily engaged in construction. The term "construction" includes new work, additions, alterations, and repairs. Construction activities are generally administered or managed from a relatively fixed place of business, but the actual construction work is performed at one or more different sites which may be dispersed geographically.

Three broad types of construction activity are covered: namely, (1) building construction by general contractors or by operative builders, (2) other construction by general contractors, and (3) construction by special trade contractors. Operative builders who build on their own account for resale are classified in this division. Separate establishments primarily engaged in construction for the investment builder are also classified in this division.

General building contractors are primarily engaged in the construction of dwellings, office buildings, stores, farm buildings and other projects of a similar character. General contractors in fields other than buildings, often referred to as heavy construction contractors, are primarily engaged in the construction of highways, streets, bridges and tunnels, docks and piers, dams and water projects; sewage collection, treatment, and disposal facilities facilities; and storm sewer systems, air fields, heavy industrial facilities and other heavy construction which involves either earth moving or the erection of structures and appurtenances, other than buildings.

Special trade contractors are primarily engaged in specialized construction activities such as plumbing, painting, electrical work and carpentry.

General contractors in both the building field and the heavy construction field usually assume responsibility for an entire construction project, but may subcontract to others those portions of the project requiring special skills or equipment. Special trade contractors may work for general contractors under subcontracts or may work directly for the owner of the proprerty.

From this division detailed business profiles were prepared on the following Industries/Business types:

Building Construction

- o General Contractors-Industrial Buildings and Warehouses

Construction Other Than Building Construction

- o Highway and Street Construction Contractors

- o Bridge, Tunnel, and Elevated Highway Construction Contractors
- o Heavy Construction Contractors, N.E.C.
- o Water, Sewer, Pipe Line, Communication and Power Line Construction Contractors

4.2.4 MANUFACTURING

The manufacturing division includes establishments engaged in the mechanical or chemical transformation of materials or substances into new products. These establishments are usually described as plants, factories, or mills and characteristically use power driven machines and materials handling equipment. Establishments engaged in assembling component parts of manufactured products are also considered manufacturing if the new product is neither a structure nor other fixed improvement. Also included is the blending of materials such as lubricating oils, plastics, resins, or liquors.

The materials processed by manufacturing establishments include products of agriculture, forestry, fishing, mining, and quarrying as well as products of other manufacturing establishments. The new product of a manufacturing establishment may be "finished" in the sense that it is ready for utilization or consumption, or it may be "semifinished" to become a raw material for an establishment engaged in further manufacturing. For example, the product of the copper smelter is the raw material used in electrolytic refineries; refined copper is the raw material used by copper wire mills; and copper wire is the raw material used by certain electrical equipment manufacturers.

The materials used by manufacturing establishments may be purchased directly from producers, obtained through customary trade channels, or secured without recourse to the market by transferring the product from one establishment to another which is under the same ownership. Manufacturing production is usually carried on for the wholesale market, for interplant transfer, or to order for industrial users, rather than for direct sale to the domestic consumer.

There are numerous borderline cases between manufacturing and other divisions of the classification system. Specific instances will be found in

the descriptions of the individual industries. There are also some manufacturing-type activities performed by establishments which are primarily engaged in activities covered by other divisions, and are thus not classified as manufacturing. A few of the more important examples are:

Agriculture, Forestry, and Fishing. Processing on farms is not considered manufacturing if the raw materials are grown on the farm and if the manufacturing activities are on a small scale without the extensive use of paid labor. Other exclusions are custom grist milling, threshing, and cotton ginning.

Mining. The dressing and beneficiating of ores; the breaking, washing, and grading of coal; the crushing and breaking of stone; and the crushing, grinding, or otherwise preparing of sand, gravel, and nonmetallic chemical and fertilizer minerals other than barite are classified in Mining.

Construction. Fabricating operations performed at the site of construction by contractors are not considered manufacturing, but the prefabrication of sheet metal, concrete, and terrazzo products and similar construction materials is included in the Manufacturing Division.

Wholesale and Retail Trade. Establishments engaged in the following types of operations are included in Wholesale or Retail Trade: cutting and selling purchased carcasses; preparing feed at grain elevators and farm supply stores; stemming leaf tobacco at wholesale establishments; and production of wiping rags; the breaking of bulk and redistribution in smaller lots, including packaging, repackaging, or bottling products such as liquors or chemicals, is also classified as Wholesale or Retail Trade. Also included in Retail Trade are establishments primarily engaged in selling, to the general public, products produced on the same premises from which they are sold, such as bakeries, candy stores, ice cream parlors, and custom tailors.

Services. Tire retreading and rebuilding, sign painting and lettering shops, and the production of motion picture films are classified in Services. Repair activities are classified as Services, except ship and boat building and repair, the rebuilding of machinery and equipment on a

factory basis, and machine shop repair, all of which are classified as manufacturing.

From this division there were no industries/business types identified for a detailed business profile.

4.2.5 TRANSPORTATION, COMMUNICATIONS, ELECTRIC, GAS, AND SANITARY SERVICES

This division includes establishments providing to the general public or to other business enterprises passenger and freight transportation, communication services, electricity, gas, steam, and water or sanitary services.

For many of the industries in this division, the establishments have activities, workers, and physical facilties distribued over an extensive geographic area. For this division, the establishment is represented by a relatively permanent office, shop, station, terminal, warehouse, etc. which is either (1) directly responsible for supervising such activities, or (2) the base from which personnel operate to carry out these activities. Many of the industries are engaged in various related activities. For example, establishments concerned with supplying electric energy, including the generating station, the network or system of transmission and distribution facilities, as well as maintenance, repair, and meter reading are all classified in the same electric services industry.

The establishments classified in this division furnish services to the general public or to other business enterprises; establishments which furnish similar services only to other establishments of the same enterprise are classified as auxiliary to the establishments or units of the enterprise which they serve. However, separate establishments primarily engaged in long-distance hauling, stevedoring, water transportation or pipe lines transportation are classified according to their activity and not as auxiliaries, even though they serve only establishments of the same company.

From this division detailed business profiles were prepared on the following Industries/Business types:

Water Transportation

- o Water Transportation Services

Electric, Gas, and Sanitary Services

- o Electric Servies
- o Natural Gas Transmission and Natural Gas Transmission and Distribution
- o Gas and Other Services Combined
- o Combination Utilities, N.E.C.
- o Water Supply, Sanitary Services, and Irrigation Services

4.2.6 WHOLESALE TRADE

This division includes establishments or places of business primarily engaged in selling merchandise to retailers; to industrial, commercial, institutional, farm, or professional business users; or to other wholesalers; or acting as agents or brokers in buying merchandise for or selling merchandise to such persons or companies.

The principal types of establishments included are: (1) merchant wholesalers - wholesalers who take title to the goods they sell, such as wholesalers, exporters, importers, cash-and-carry wholesalers, drop shippers, wagon distributors, retailer cooperative warehouses, terminal elevators, and cooperative buying associations; (2) sales branches and sales office (but not retail stores) maintained by manufacturing or mining enterprises apart from their plants or mines for the purpose of marketing their products; (3) agents, merchandise or commodity brokers, and commission merchants; (4) petroleum bulk stations; and (5) assemblers, buyers, and associations engaged in the cooperative marketing of farm products. Establishments primarily engaged in the wholesale distribution of used products are classified on the basis of the products sold.

The chief functions of establishments included in Wholesale Trade are selling goods to trading establishments, or to industrial, commercial,

institutional, farm, and professional business users; and bringing buyer and seller together. In addition to selling, functions frequently performed by wholesale establishments include maintaining inventories of goods; extending credit; physically assembling, sorting, and grading goods in large lots; breaking bulk and redistribution in smaller lots; delivery; refrigeration; and various types of promotion such as advertising and label designing.

From this division there were no industries/business types identified for a detailed business profile.

4.2.7 RETAIL TRADE

This division includes establishments engaged in selling merchandise for personal or household consumption, and rendering services incidental to the sale of the goods. In general, retail establishments are classified by kind of business according to the principal lines of commodities sold (groceries, hardware, etc.), or the usual trade designation (drug store, cigar store, etc.). Some of the important characteristics of retail trade establishments are: the establishment is usually a place of business and is engaged in activities to attract the general public to buy; the establishment buys or receives merchandise as well as sells; the establishment may process its products, but such processing is incidental or subordinate to selling; the establishment is considered as retail in the trade; and the establishment sells to customers for personal or household use. Not all of these characteristics need be present and some are modified by trade practice.

For the most part, establishments engaged in retail trade sell merchandise to the general public for personal or household consumption. Exceptions to this general rule are made necessary by trade practices. For example, lumber yards and paint, glass and wallpaper stores are included in Retail Trade if they sell to the general public, even if a higher proportion of their sales is made to contractors. However, establishments that sell exclusively to business establishments, institutional and industrial users, or contractors are classified in Wholesale Trade.

Buying of goods for resale to the consumer is a characteristic of retail trade establishments that particularly distinguishes them from the agricultural and extractive industries. For example, farmers who sell only their own produce at or from the point of production are not classified as retailers.

From this division there were no industries/business types identified for a detailed business profiles.

4.2.8 FINANCE, INSURANCE, AND REAL ESTATE

This division includes establishments operating primarily in the fields of finance, insurance, and real estate. Finance includes banks and trust companies, credit agencies other than banks, holding (but not predominantly operating) companies, other investment companies, brokers and dealers in securities and commodity contracts, and security and commodity exchanges. Insurance covers carriers of all types of insurance, and insurance agents and brokers. Real estate includes owners, lessors, lessees, buyers, sellers, agents, and developers of real estate.

From this division detailed business profiles were prepared on the following industries/business types:

Insurance Agents, Brokers and Service

- Insurance Agents, Brokers and Service

Real Estate

- Subdividers and Developers

4.2.9 SERVICES

This division includes establishments primarily engaged in providing a wide variety of services for individuals, business and government establishments, and other organizations. Hotels and other lodging places; establishments providing personal, business, repair, and amusement services; health, legal, engineering, and other professional services; educational institutions; membership organizations, and other miscellaneous services, are included.

Establishments which provide specialized services closely allied to agriculture, mining, transportation, etc., are classified in their respective divisions.

From this division detailed business profiles were prepared on the following Industries/Business types:

Industry/Business Type

Engineering Services

- o Soils and Foundation Engineering Services
- o Sanitary Engineering Services
- o Mining and Metallurgical Engineering Services
- o Civil Engineering Services

Architectural Services

- o Architectural Services

Land Surveying Services

- o Land Surveying Services

Management and Consulting Services

- o City Planners
- o Site Locators

Services, not elsewhere classified (N.E.C.)

- o Weather Forecasters

4.3 SELECTED BUSINESS PROFILES AND SUMMARY PROFILE INFORMATION

Business profiles were prepared for the 48 industry/business types listed in Section 4.2. These 48 were selected, from analysis of over 200 industry and 1000 business types, as having the greatest potential for use of remote sensing technology. Because of the many pages of information compiled in these profiles, only five business profiles representative of major industrial groups are presented in Figures 4-1 to 4-5.

BUSINESS TYPE: Field Crop Farms

NUMBER OF ESTABLISHMENTS: 788,422

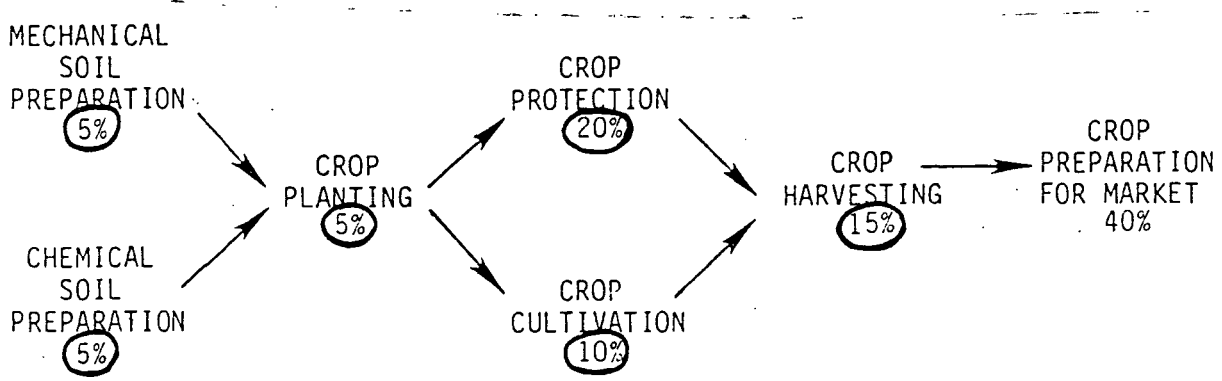
GROSS REVENUES: $82,950M

AVERAGE COMPANY REVENUES: $105K

DESCRIPTION:

Farms are places on which agricultural operations generating income equal or greater than $2,500 per year are conducted under individual management. Field crop farm income is generated by the production and sale of field crops including wheat and other cash grains, rice, corn, soybeans, cotton, tobacco, sugar, potatoes, vegetables, melons and berries. Specific activities include soil preparation, crop planting protection, cultivation, harvesting and preparation for market and the associated assessment and planning activities that relate to each. The planning activities related to all but the crop preparation for market activities require cartographic information inputs.

RELATIONSHIP OF THE MAJOR OPERATIONAL ACTIVITIES AND THE PERCENT OF REVENUE ATTRIBUTED TO EACH:



(%) - Information Intensive Activities

Figure 4-1

BUSINESS TYPE: Field Crop Farms

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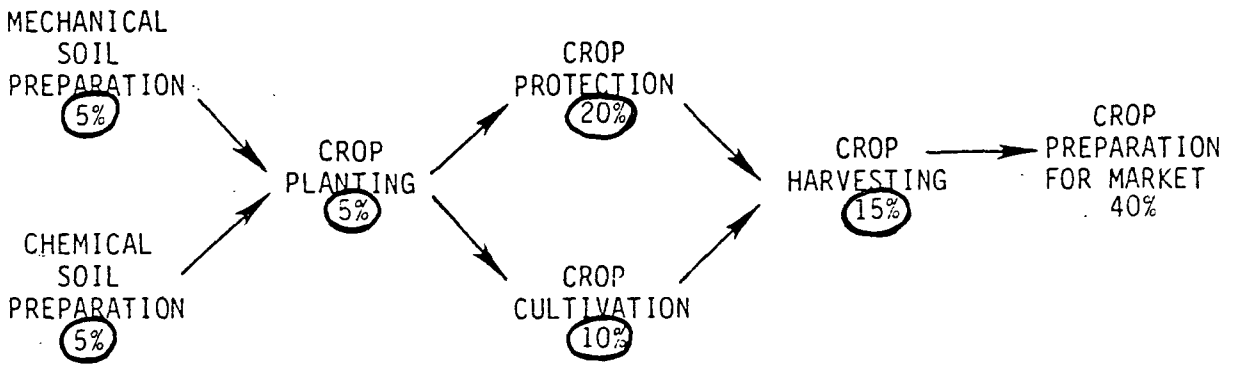
RELATIONSHIP OF THE MAJOR OPERATIONAL ACTIVITIES AND THE PERCENT OF REVENUE ATTRIBUTED TO EACH:



(%) - Information Intensive Activities

Figure 4-1

BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
Mechanical Soil Preparation	Planning:				
	Mechanical soil treatment schedule	Soil types	≈200	3-5 years	VIS/SWIR/TIR
		Topography	1:24,000 (≈6m)	3-5 years	VIS
	o Methods	Field layout	Field size (≈50m)	Yearly	VIS
	o Locations	Planting intentions	Field size (≈50m)	Seasonal	NRS
	o Windows	Soil temperature	≈200m	5-10 days	TIR
		Soil moisture	≈200m	5-10 days	TIR
		Weather forecast	---	Daily	NRS
	Treatment:				
	Not Information intensive				
Chemical Soil Preparation	Soil Condition Evaluation:				
	Chemical soil condition:	Soil type	≈200m	3-5 years	VIS/SWIR/TIR
		Chemical soil analysis	---	1-2 years	NRS (sampling)
	o Nutrient level	Multi-season cropping history	Field size (50m)	Seasonal	VIS
	o Ph	Recent climatic history	---	Monthly	NRS (records)
		Chemical application history	Field size (50m)	Seasonal	NRS (records)

*NRS - Not Remote Sensing

Figure 4-1

BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
	Treatment Planning:				
	Integrated chemical treatment strategy:	Soil type	≃200m	3-5 years	VIS/SWIR/TIR
	o Fertilizer/ chemical selection	Fertilizer/chemical costs	---	---	NRS
		Planting intentions	Field size (≈50m)	Seasonal	NRS
	o Application windows	Application costs	---	---	NRS
	o Environmental impact	Topography	1:24,000	3-5 years	VIS
	o Yield improvement	Proximity of environmentally controlled areas	1:24,000	Yearly	VIS
	o Treatment cost	Pest types/cycles	---	---	NRS
	Application:				
	Not Information intensive				
Crop Planting	Scheduling:				
	Planting Schedule	Topography	1:24,000 (6m)	3-5 years	VIS
	o Locations				
	o Windows	Soil types	≃200m	3-5 years	VIS/SWIR/TIR
		Soil Temperature	≃200m	5-10 days	TIR
		Soil moisture	≃200m	5-10 days	TIR
		Five-day weather forecast	---	Daily	NRS

*NRS - Not Remote Sensing

Figure 4-1 (cont.)

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
	Planting:				
	Not Information Intensive				
Crop Protection (Weed Control)	Assessment:				
	Encroachment locations and severity	Crop Types	Field Size (≃50m)	Seasonal	VIS
		Weed Types	Sub-Field	10-20 days	VIS
		Crop Vigor	Sub-Field (≃10m)	10-20 days	SWIR
	Planning:				
	Control Strategy:	Crop Types	Field Size (≃50m)	Seasonal	VIS
	o Herbicide compatibility	Crop Vigor	Sub-Field (≃10m)	10-20 days	SWIR
	o Application Windows				
	o Yield Improvements	Proximity of Environmentally Controlled Areas	1:24,000 (≃6m)	Yearly	VIS
		Weed Types	Sub-Field (≃10m)	10-20 days	VIS
		Herbicide Costs	---	Seasonal	NRS
		Mechanical Control Costs	---	Seasonal	NRS
		Weather	---	Daily	NRS
	Application				
	Not Information Intensive				

*NRS - Not Remote Sensing

Figure 4-1 (cont.)

BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
Crop Protection (Insect and Disease Control)	Forecasting:				
	Damage Prediction Warning	Crop Types	Field Size (≈50m)	Seasonal	VIS
		Soil Temperature	≈200m	2-10 days	TIR
		Soil Moisture	≈200m	2-10 days	TIR
		Topography	1:24,000 (≈6m)	1-2 years	VIS
		Egg Counts	--	Seasonal	NRS (Sampling)
	Assessment:				
	Damage Locations and Severity	Crop Types	Field Size (≈50m)	Seasonal	VIS
		Crop Vigor	Sub-Field (≈10m)	2-10 days	SWIR (Sampling)
	Planning:				
	Integrated Pest Management Strategy	Crop Types	Field Size (≈50m)	Seasonal	VIS
	o Spray Compatibility	Crop Vigor	Sub-Field (≈10m)	2-10 days	SWIR
	o Application Windows				
	o Yield Improvements	Proximity of Environmental Controlled Areas	1:24,000 (≈6m)	Yearly	VIS
	o Environmental Impact	Pest Types	---	Seasonal	NRS
		Pest Cycles	---	Seasonal	NRS
		Spray Costs	---	Seasonal	NRS

*NRS - Not Remote Sensing

Figure 4-1 (cont.)

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
	o Flight Plan o Timing	Weather	---	Daily	NRS
	Application: Not Information Intensive				
Crop Cultivation	Requirements Forecasting: Soil nutrient level	Soil type	≈200m	3-5 years	VIS/SWIR/TIR
		Chemical soil analysis	---	1-2 years	NRS (sampling)
		Multi-season cropping history	Field size (≈50m)	Seasonal	VIS
		Current crop type	Field size (≈50m)	Seasonal	VIS
		Recent climatic history	---	Monthly	NRS (records)
		Fertilizer application history	Field size (≈50m)	Seasonal	NRS (records)
	Assessment: Nutritional crop stress	Crop types	Field size (≈50m)	Seasonal	VIS
		Crop biostage	Field size (≈50m)	8-10 days	VIS
		Crop vigor	Sub-field (≈10m)	8-10 days	SWIR

*NRS - Not Remote Sensing

Figure 4-1 (cont.)

BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION *REQUIRED*	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
	Specification and Scheduling:				
	Application strategy	Nutrient deficiency (from forecasting and assessment)	---	---	---
	o Fertilizer selection	Crop type	Field size (≈50m)	Seasonal	VIS
	o Application method	Soil type	≈200m	3-5 years	VIS/SWIR/TIR
	o Application windows	Fertilizer costs	---	Seasonal	NRS
	o Yeild improvement	Application costs	---	Seasonal	NRS
	o Strategy cost	Weather forecasts	---	Daily	NRS
	Application:				
	Not Information Intensive				
Crop Harvesting	Harvest Schedule:	Crop type	Field size (≈50m)	Seasonal	VIS
	o Method	Crop biostage	Field size (≈50m)	5-10 days	VIS
	o Windows	Topography	1:24,000 (≈6m)	3-5 years	VIS
		Soil moisture	≈200m	5-10 days	TIR
		Five-day weather forecast	---	Daily	NRS

*NRS - Not Remote Sensing

Figure 4-1 (cont.)

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
		Labor costs	---	Seasonal	NRS
		Energy costs	---	Seasonal	NRS
	Harvesting: Not an Information intensive function				
Crop Preparation for Market	Not an Information intensive function				

*NRS - Not Remote Sensing

Figure 4-1 (cont.)

BUSINESS PROFILE

BUSINESS TYPE: Crude Petroleum & Natural Gas

NUMBER OF ESTABLISHMENTS: 8,524

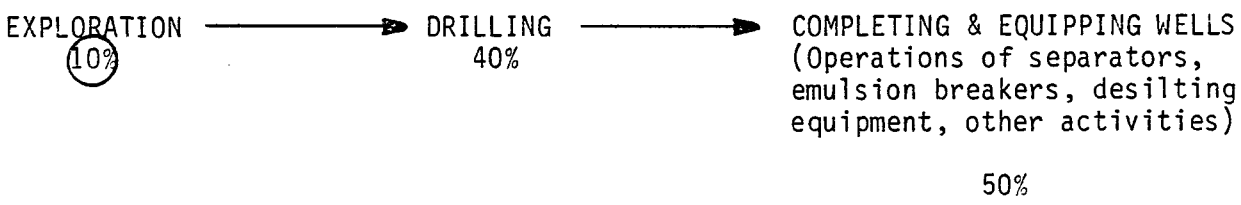
GROSS REVENUES: $56,465 M

AVERAGE COMPANY REVENUES: $6.6 M

DESCRIPTION:

Operation of oil and gas field properties. Such activities include exploration for crude petroleum and natural gas; drilling, completing, and equipping wells; operation of separators, emulsion breakers, desilting equipment; and all other activities incident to making oil and gas marketable up to the point of shipment from the producing property.

RELATIONSHIP OF THE MAJOR OPERATIONAL ACTIVITIES AND THE PERCENT OF REVENUE ATTRIBUTED TO EACH:



(%) - Information Intensive Activities

Figure 4-2

BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
Exploration	Identification of potential deposits of oil and natural gas	Vegetative Patterns	10-100 m	3 per year	VIS
		Rock Types	30-200 m	1-3 years	VIS, SWIR, TIR
		Rock Formation	30-200 m	3-5 years	VIS, TIR
		Rock Alteration	30-200 m	2x per year/ 2-3 years	VIS, TIR
	Environmental Impact Assessment	Tonal & Color Patterns	10-100 m	2-3 years	VIS
		Drainage Patterns	10-200 m	3-5 years or less	VIS, SWIR, TIR
		Strata Attitude	10-30 m	1-3 years	VIS
	Monitoring clean-up activities	Fold Elements	30-100 m	1-3 years	VIS
		Faults, Fractures, Joints	10-20 m	1-3 years	VIS
		Lineaments	10-100 m	Seasonal/ 3-5 years	VIS
		Structural Anomalies	10-100 m	3-5 years	VIS
		Terrain Type	30-100 m	3-5 years	VIS, TIR
		Thermal Anomalies	10-50 m	1 year/ diurnally	TIR
		Magnetic Field Strength	100 m	1/year	MAG
		Seismic Profiles	-	-	NRS
		Gravity Field Strength	100 m	1/year	GRAV
		Core Data	-	-	NRS
		Land Use	10-30 m	1/year	VIS
Drilling	Information satisfied by above activities				
Completing and Equipping Wells	Information satisfied by above activities				
Operations of Separators	Not Information Intensive				

*NRS - Not Remote Sensing

Figure 4-2 (cont.)

BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
Emulsion Breakers	Not Information Intensive				
Desilting Equipment	Not Information Intensive				
Other Activities	Not Information Intensive				

NRS - Not Remote Sensing

Figure 4-2 (cont.)

BUSINESS TYPE: Heavy Construction Contractors, not elsewhere classified

NUMBER OF ESTABLISHMENTS: 8,342

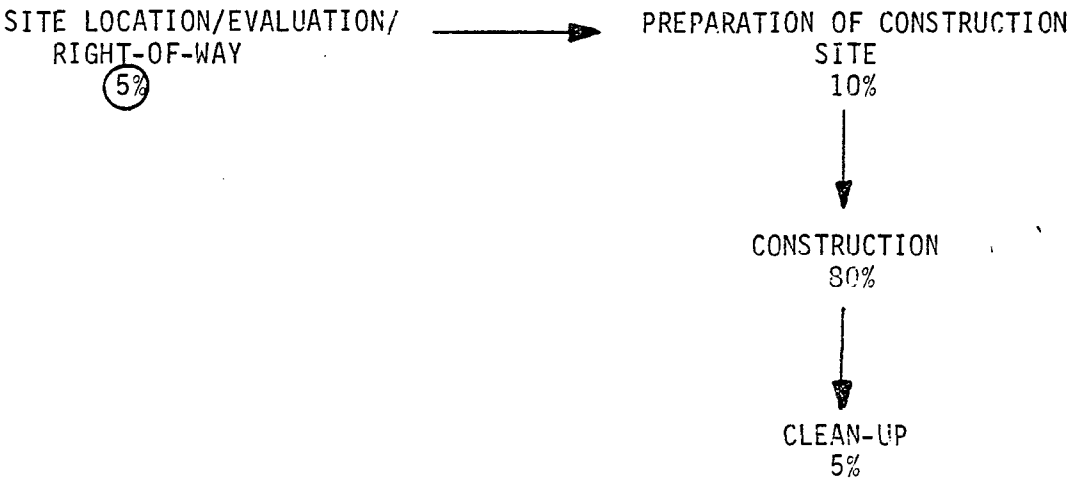
GROSS REVENUES: $30,701.8 M

AVERAGE COMPANY REVENUES: $3.7 M

DESCRIPTION:

General contractors primarily engaged in the construction of heavy complexes, dams, and reservoirs, harbor and port facilities, missile facilities, oil refineries, subways, water, and sewage treatment plants, light and power plants, industrial ovens and incenerators, flood control projects, and dredging and demolition contractors.

RELATIONSHIP OF THE MAJOR OPERATIONAL ACTIVITIES AND THE PERCENT OF REVENUE ATTRIBUTED TO EACH:



(%) - Information Intensive Activities

Figure 4-3

BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
Site Location/ Evaluation/ Right-of-way	Ownership boundaries and land acquisition	Cadastral	-	-	NRS
		Faults, fractures, joints	10-20 m	1-3 years	VIS
		Topographic	10-30 m	1-3 years	VIS
		Geologic Structure	10-200 m	3-5 years	VIS, TIR
	Environmental Impact	Soil Types	10-100 m	3-5 years	VIS
		Drainage Patterns	10-100 m	3-5 years	VIS, SWIR, TIR
		Land Use	10-30 m	1 year	VIS
	Engineering geology assess-ment	Lineaments	10-30 m	3-5 years	VIS
		Core Data	-	-	NRS
	Flood plain mapping				
Preparation of Site	Information satisfied by above activities				
Construction	Information satisfied by above activities				
Clean-Up	Information satisfied by above activities				

*NRS - Not Remote Sensing

Figure 4-3 (cont.)

BUSINESS PROFILE

BUSINESS TYPE: Electric Services

NUMBER OF ESTABLISHMENTS: 383

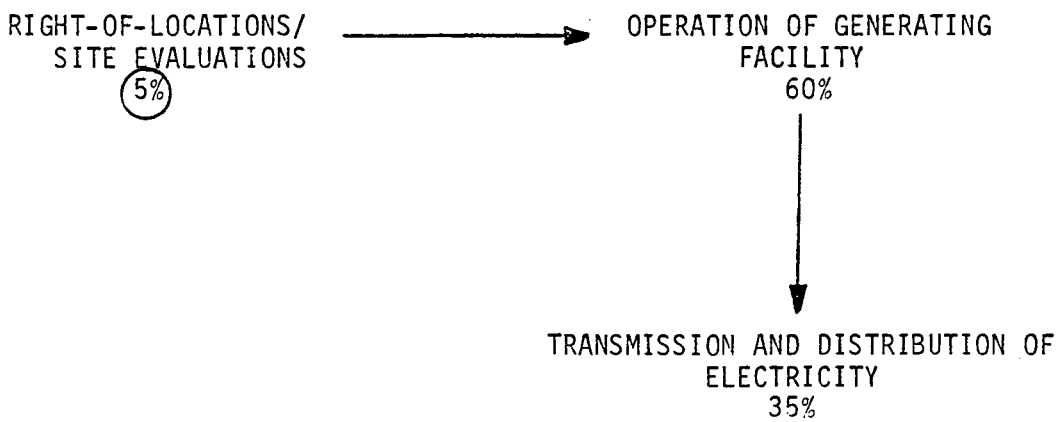
GROSS REVENUES: $77,716 M

AVERAGE COMPANY REVENUES: $203 M

DESCRIPTION:

Engaged in the generation, transmission and/or distribution of electric energy for sale.

RELATIONSHIP OF THE MAJOR OPERATIONAL ACTIVITIES AND THE PERCENT OF REVENUE ATTRIBUTED TO EACH:



(%) - Information Intensive Activities

Figure 4-4

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
Right-of-way/ Site Evaluation	Ownership boundaries and acquisition	Cadastial	-	-	NRS
		Census data	-	-	NRS
		Topographic	10-30 m	1-3 years	VIS
		Ground Surveys	-	-	NRS
	New Generating site Evaluation	Demographic data	-	-	NRS
		Hydrologic data	-	-	NRS
		Land Use	10-30 m	1 year	VIS
	Transmission Line Right-of-ways	Faults, Fractures, Joints	10-20 m	1-3 years	VIS
		Land Acquisition	-	-	NRS
	Environmental Impact and Monitoring				
OPERATIONS	Not Information Intensive				
DISTRIBUTION	Not Information Intensive				

*NRS - Not Remote Sensing

Figure 4-4 (cont.)

BUSINESS PROFILE

BUSINESS TYPE: Subdividers and Developers

NUMBER OF ESTABLISHMENTS: 26,095

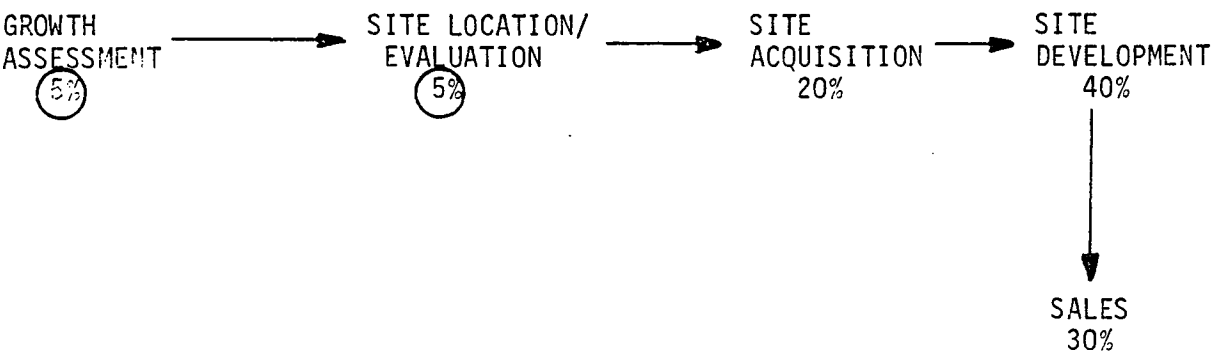
GROSS REVENUES: $6394.5 M

AVERAGE COMPANY REVENUES: $245 K

DESCRIPTION:

Establishments primarily engaged in subdividing real property into lots, except cemetery lots, in developing it for resale on their own account or for others.

RELATIONSHIP OF THE MAJOR OPERATIONAL ACTIVITIES AND THE PERCENT OF REVENUE ATTRIBUTED TO EACH:



(%) - Information Intensive Activities

Figure 4-5

BUSINESS PROFILE

INFORMATION REQUIREMENTS:

ACTIVITY	MODELS/OUTPUTS	KEY INFORMATION INPUTS	SCALE/RESOLUTION REQUIRED	FREQUENCY	APPLICABILITY OF REMOTE SENSING*
Growth Assessment	Environmental Impact	Land Use	10 m	1 year	VIS
		Census data	-	-	NRS
	Site Evaluations	Transportation Networks	10 m	1 year	VIS
		Demographic data	-	-	NRS
Site Location	Ownership bounderies and property values	Cadastral	-	-	NRS
		Topographic	10-30 m	1-3 years	VIS
		Drainage Patterns	10-100 m	3-5 years	VIS, SWIR, TIR
		Soil types	10-100 m	3-5 years	VIS
		Flood plain history	-	-	NRS
		Ground surveys	-	-	NRS
Site Acquisition	Information satisfied by above activities				
Site Development	Information satisfied by above activities				
Sales	Information satisfied by above activities				

*NRS - Not Remote Sensing

Figure 4-5 (cont.)

A compilation of the information derived from all the profiles is shown on the Summary Business Profile Analysis chart (Table 4-1) and the Summary Business Profile Analysis-Landsat chart (Table 4-2). These summary charts indicate which industries/businesses have the greatest need for remote sensing/Landsat information, and illustrate the business types and establishments within industries which have the greatest potential to use Landsat information now and in the future.

4.4 ANALYSIS OF PROFILE INFORMATION

In this section is a series of graphic presentations prepared from the results of the business profiles (Figures 4-6 to 4-9). These figures illustrate a relative ranking (for years 1980, 1982, 1990, and 1995) of the business types analyzed in this study. The ranking is based upon the revenue weighted effect of Landsat (see Section 2.3.3 for definition) upon individual business establishments. The diagonal lines are lines of constant "Revenue Weighted Effect of Landsat" for an industry or business types. Industries or businesses which are plotted at different places along the same line have the same total "Revenue Weighted Effect of Landsat" but have a different number of establishments in them. For example, in Figure 4-7 (1982), G2, Forest Farms and U2, Natural Gas Transmission and Distribution have essentially the same "Revenue Weighted Effect of Landsat" totals (i.e., $100 M), but G2 contains approximately 16,000 establishments while U2 has only 120. U2, therefore, has a relatively large "Revenue Weighted Effect of Landsat" per establishment and would be a likely candidate industry to establish an in-house Landsat analysis capability. On the other hand, G2's smaller "Revenue Weighted Effect of Landsat" per establishment indicates it would more likely utilize products provided by the analysis service industry.

4.5 GENERAL SUMMARY OF RESULTS FROM BUSINESS PROFILES

This section presents a summary evaluation of the potential Landsat impact on industries in each of the nine SIC Code Divisions. This evaluation, based upon the business profile analysis, will highlight those industries with significant potential for Landsat utilization. Also, those industries in which involvement with Landsat is unlikely are discussed.

TABLE 4-1

SUMMARY OF BUSINESS PROFILE ANALYSIS

		ECONOMIC SUMMARY OF INDUSTRIES			INFORMATION EFFECT ON REVENUES			SENSING EFFECT ON REVENUES		
INDUSTRY	BUSINESS TYPE	GROSS REVENUES ($ MILLIONS)	NUMBER OF ESTABLISHMENTS	AVERAGE REVENUES PER ESTABLISHMENT ($ MILLIONS)	% OF ESTIMATED BUSINESS RESOURCES DEVOTED TO INFORMATION	REVENUE WEIGHTED EFFECT OF INFORMATION ($ MILLIONS)	AVERAGE REVENUE EFFECT OF INFORMATION PER ESTABLISHMENT	% INFO REQUIREMENTS POTENTIALLY AVAILABLE FROM GENERAL R/S	REVENUE WEIGHTED EFFECT OF REMOTE SENSING ($ MILLIONS)	AVERAGE REVENUE WEIGHTED EFFECT OF R/S PER ($ MILLIONS)
Agricultural Production (Crops)	Field Crops Farms	82,950	788,422	.105	8	6,636	.008	53	3,517	.005
	Vine and Tree Crop Farms	4,090	47,847	.086	4	164	.003	58	95	.002
Agricultural Production (Livestock)	Livestock Farms/Ranches	19,605	227,540	.086	7	1,372	.006	80	1,097	.005
Soil Preparation Services	Plowing and Seed Bed Preparation	118	352	.336	10	12	.014	71	8	.02
	Fertilizer Application and Other Chemical Treatment of Soil	117	977	.119	20	23	.024	38	9	.009
Crop Planting, Cultivating and Protection Services	Planting Services	13	205	.065	15	2	.010	38	1	.004
	Fertilizer Application Services (after planting)	31	334	.094	20	6	.019	50	3	.009
	Weed Control Services (after planting)	40	468	.086	15	6	.013	57	4	.007
	Crop Insect and Disease Control Services	328	1,132	.290	20	66	.058	58	38	.03
Harvesting Services	Harvesting Services	204	1,410	.144	5	10	.007	57	6	.004
Landscape Counselling and Planning	Landscape Architects	119	1,283	.093	30	36	.078	62	24	.02
Forestry	Forest Farms	6,720	16,000	.419	10	672	.042	60	403	.02
Forestry Services	Forestry Services	363	1,000	.363	20	73	.073	60	44	.04
Hunting, Trapping and Game Propagation	Wildlife Management	425	5,000	.085	30	128	.026	56	71	.01
Commercial Fishing	Catching of Finfish	847	3,534	.240	10	85	.024	78	66	.02
Metal Mining	Iron Ores	2,052	97	21.1	5	102.6	1.06	80	82	.8
	Copper Ores	2,190	130	18.4	5	119.5	.92	71	84	.6
	Metal Mining Services	173	152	1.1	20	34.6	.23	88	30	.2
Bituminous Coal and Lignite	Bituminous Coal and Lignite	17,827	4,892	3.6	5	891.4	.18	71	633	.1
	Bituminous Coal and Lignite Mining Services	545	285	1.9	10	54.5	.19	71	39	.1
Oil and Gas Extraction	Crude Petroleum and Natural Gas	56,465	8,524	6.6	10	5646.5	.66	89	5025	.6
	Drilling Oil and Gas Wells	6,014	2,180	2.8	20	1202.8	.55	71	854	.4
	Oil and Gas Exploration Services	*903*	*1,019*	*0.9*	*100*	*903*	*.89*	*89*	*804*	*.8*
Mining and Quarrying of of Non-Metallic Minerals	Crushed and Broken Stone	2,829	1,957	1.4	5	141.5	.07	100	141.	.07
	Sand and Gravel	2,163	2,614	0.8	5	108.1	.04	100	108	.04
	Nonmetallic Minerals (Except Fuels) Services	158	141	1.1	5	7.9	.06	88	7	.05
Building Construction	*General Contractors - Industrial Buildings and Warehouses*	18,547	8,259	2.2	5	927.3	.11	71	658	.08
Construction, Other Than Building Construction	Highway and Street Construction Contractors	15,600	11,748	1.3	5	780.0	.07	75	585	.05
	Bridge, Tunnel, and Elevated Highway Construction Contractors	3,196	979	3.3	5	159.8	.16	71	113	.1
	Water, Sewer, Pipeline, Communication, and Power Line Construction Contractors	13,522	10,227	1.3	5	676.1	.07	75	507	.05
	Heavy Construction Contractors, not elsewhere classified (N.E.C.)	30,702	8,142	3.7	5	1535.1	.18	78	1197	.1

TABLE 4-1 (cont.)

SUMMARY OF BUSINESS PROFILE ANALYSIS

		ECONOMIC SUMMARY OF INDUSTRIES			INFORMATION EFFECT ON REVENUES			SENSING EFFECT ON REVENUES		
INDUSTRY	BUSINESS TYPE	GROSS REVENUES ($ MILLIONS)	NUMBER OF ESTABLISHMENTS	AVERAGE REVENUES PER ESTABLISHMENT ($ MILLIONS)	% OF ESTIMATED BUSINESS RESOURCES DEVOTED TO INFORMATION	REVENUE WEIGHTED EFFECT OF INFORMATION ($ MILLIONS)	AVERAGE REVENUE EFFECT OF INFORMATION PER ESTABLISHMENT	% INFO REQUIREMENTS POTENTIALLY AVAILABLE FROM GENERAL R/S	REVENUE WEIGHTED EFFECT OF REMOTE SENSING ($ MILLIONS)	AVERAGE REVENUE WEIGHTED EFFECT OF R/S PER ($ MILLIONS)
Water Transportation	Water Transportation	11,849	4,452	2.7	3	355.5	.08	75	267	.06
Electric, Gas, and Sanitary Services	Electric Services	77,716	383	203.0	5	3885.8	10.1	33	1282	3.0
	Natural Gas Transmission and Distribution	22,011	122	180.0	5	1100.6	9.0	44	484	4.0
	Gas and Other Combined	59,860	1,356	44.1	5	2993.0	2.2	44	1317	1.0
	Combination Utilities, not elsewhere classified	46,223	311	149.0	5	2311.2	7.4	44	1017	3.0
	Water Supply, Sanitary Services, and Irrigation Services	4,514	6,584	0.7	15	677.1	.1	75	508	.08
Insurance Agents, Brokers, and Service	Insurance Agents, Brokers, and Service	10,139	35,950	0.3	30	3041.7	.08	36	1095	.03
Real Estate	Subdividers and Developers, Except Cemeteries	6,194	26,095	0.2	10	639.5	.02	50	320	.01
Engineering Services	Soils and Foundation Engineering Services	464	619	.750	40	186	.300	100	186	.3
	Sanitary Engineering Services	1,210	1,608	.751	30	362	.225	58	210	.1
	Mining and Metallurgical Engineering Services	93	99	.938	20	19	.188	58	11	.1
	Civil Engineering Services	2,140	2,846	.750	20	427	.150	69	294	.1
Architectural Services	Architectural Services	5,110	9,879	.518	15	767	.78	27	207	.02
Land Surveying Services	Land Surveying Services	1,080	4,690	.231	100	1,084	.231	75	813	.2
Management and Consulting Services	City Planners	715	800	.894	40	286	.358	59	169	.2
	Site Locators	358	400	.894	70	250	.625	50	125	.3
Services N.E.C.	Weather Forecasters	25	100	.250	35	9	.088	89	8	.08

Table 4-2

SUMMARY OF BUSINESS PROFILE ANALYSIS - LANDSAT

INDUSTRY	BUSINESS TYPE	PERCENT OF REMOTELY SENSIBLE INFORMATION AVAILABLE FROM LANDSAT				REVENUE WEIGHTED EFFECT OF LANDSAT ($ MILLIONS)				AVERAGE REVENUE EFFECT OF LANDSAT PER ESTABLISHMENT ($ MILLIONS)			
		1980	1982	1990	1995	1980	1982	1990	1995	1980	1982	1990	1995
Agricultural Production (Crops)	Field Crop Farms	34%	56%	80%	100%	1200	1970	2810	3520	.002	.003	.004	.005
	Vine and Tree Crop Farms	14%	43%	71%	100%	10	40	70	100	.0003	.0008	.001	.002
Agricultural Production	Livestock Farms/Ranches	58%	79%	80%	100%	640	870	880	1100	.003	.004	.004	.005
Soil Preparation Services	Plowing and Seed Bed Preparation	20%	100%	100%	100%	2	10	10	10	.005	.02	.02	.02
	Fertilizer Applications and Other Chemical Treatment of Soil	17%	50%	50%	100%	2	5	5	10	.002	.005	.005	.009
Crop Planting, Cultivating and Protection Services	Planting Services	20%	80%	80%	100%	<1	<1	<1	1	.001	.004	.004	.005
	Fertilizer Application Services (after planting)	67%	83%	100%	100%	2	2	3	3	.006	.007	.009	.009
	Weed Control Services (after planting)	25%	25%	75%	100%	1	1	3	4	.002	.002	.006	.009
	Crop Insect and Disease Control Services	14%	43%	71%	100%	5	15	30	40	.005	.01	.02	.03
Harvesting Services	Harvesting Services	50%	75%	75%	100%	3	5	5	5	.002	.003	.003	.003
Landscape Counseling and Planning	Landscape Architects	26%	38%	63%	100%	5	10	15	20	.005	.007	.01	.02
Forestry	Forest Farms	22%	22%	89%	100%	90	90	360	400	.006	.006	.02	.03
Forestry Services	Forestry Services	22%	22%	89%	100%	10	10	40	40	.01	.01	.04	.04
Hunting, Trapping and Game Propagation	Wildlife Management	*	*	20%	80%	*	*	15	60	*	*	.003	.01
Commercial Fishing	Catching of Finfish	*	*	*	*	*	*	*	*	*	*	*	*

*Less than 1%.

Table 4-2 (cont.)

SUMMARY OF BUSINESS PROFILE ANALYSIS - LANDSAT

INDUSTRY	BUSINESS TYPE	PERCENT OF REMOTELY SENSIBLE INFORMATION AVAILABLE FROM LANDSAT				REVENUE WEIGHTED EFFECT OF LANDSAT ($ MILLIONS)				AVERAGE REVENUE EFFECT OF LANDSAT PER ESTABLISHMENT ($ MILLIONS)			
		1980	1982	1990	1995	1980	1982	1990	1995	1980	1982	1990	1995
Metal Mining	Iron Ores	62	62	88	88	50	50	70	70	.5	.5	.7	.7
	Copper Ores	43	43	100	100	40	40	80	80	.3	.3	.6	.6
	Metal Mining Services	67	67	93	93	20	20	30	30	.1	.1	.2	.2
Bituminous Coal and Lignite	Bituminous Coal and Lignite	80	80	100	100	510	510	630	630	.1	.1	.1	.1
	Bituminous Coal and Lignite Mining Services	80	80	100	100	30	30	40	40	.1	.1	.1	.1
Oil and Gas Extraction	Crude Petroleum and Natural Gas	62	62	81	88	3120	3120	4070	4420	.4	.4	.5	.5
	Drilling Oil and Gas Wells	60	60	100	100	510	510	850	850	.2	.2	.4	.4
	Oil and Gas Exploration Services	62	62	81	88	500	500	650	710	.5	.5	.6	.7
Mining and Quarrying of Non-Metallic Minerals	Crushed and Broken Stone, Including RIPRAP	40	40	60	80	60	60	80	110	.03	.03	.04	.06
	Sand and Gravel	60	60	80	100	60	60	90	110	.02	.02	.03	.04
	Nonmetallic Minerals (Except Fuels) Services	71	71	86	100	5	5	5	5	.03	.03	.04	.05
Building Construction	General Contractors - Industrial Buildings and Warehouses	60	60	100	100	400	400	660	660	.05	.05	.1	.1
Construction, Other Than Building Construction	Highway and Street Construction Contractors	50	50	100	100	290	290	580	580	.02	.02	.05	.05
	Bridge, Tunnel, and Elevated Highway Construction Contractors	40	40	100	100	50	50	110	110	.05	.05	.1	.1
	Water, Sewer, Pipeline, Communication, and Power Line Construction Contractors	50	50	100	100	250	250	510	510	.02	.02	.05	.05

Table 4-2 (cont.)

SUMMARY OF BUSINESS PROFILE ANALYSIS - LANDSAT

INDUSTRY	BUSINESS TYPE	PERCENT OF REMOTELY SENSIBLE INFORMATION AVAILABLE FROM LANDSAT				REVENUE WEIGHTED EFFECT OF LANDSAT ($ MILLIONS)				AVERAGE REVENUE EFFECT OF LANDSAT PER ESTABLISHMENT ($ MILLIONS)			
		1980	1982	1990	1995	1980	1982	1990	1995	1980	1982	1990	1995
	Heavy Construction Contractors, not elsewhere classified (N.E.C.)	43	43	86	100	510	510	1030	1200	.05	.05	.1	.1
Water Transportation	Water Transportation	*	*	*	50	*	*	*	130	*	*	*	.03
Electric, Gas, and Sanitary Services	Electric Services	*	50	100	100	*	640	1280	1280	*	2	3	3
	Natural Gas Transmission and Distribution	10	25	75	100	50	120	360	480	.4	1	3	4
	Gas and Other Combined	10	25	75	100	130	330	990	1320	.1	.2	.7	1
	Combination Utilities, not elsewhere classified	10	25	75	100	100	250	760	1020	.3	.8	2	3
	Water Supply, Sanitary Services, and Irrigation Services	75	75	100	100	380	380	510	510	.05	.05	.1	.1
Insurance Agents, Brokers, and Service	Insurance Agents, Brokers, and Service	20	40	80	80	220	440	880	880	.006	.01	.02	.02
Real Estate	Subdividers and Developers, Except Cemeteries	10	25	100	100	30	80	320	320	.001	.003	.01	.01
Engineering Services	Soils and Foundation Engineering Services	25%	25%	25%	100%	50	50	50	190	.08	.08	.08	.3
	Sanitary Engineering Services	27%	36%	54%	54%	60	80	110	110	.04	.05	.07	.07
	Mining and Metallurgical Engineering Services	*	14%	100%	100%	*	2	10	10	*	.02	.1	.1
	Civil Engineering Services	27%	36%	55%	55%	80	110	160	160	.03	.04	.06	.06
Architectural Services	Architectural Services	33%	33%	33%	100%	70	70	70	210	.007	.007	.007	.02
Land Surveying Services	Land Surveying Services	*	*	*	33%	*	*	*	270	*	*	*	.06

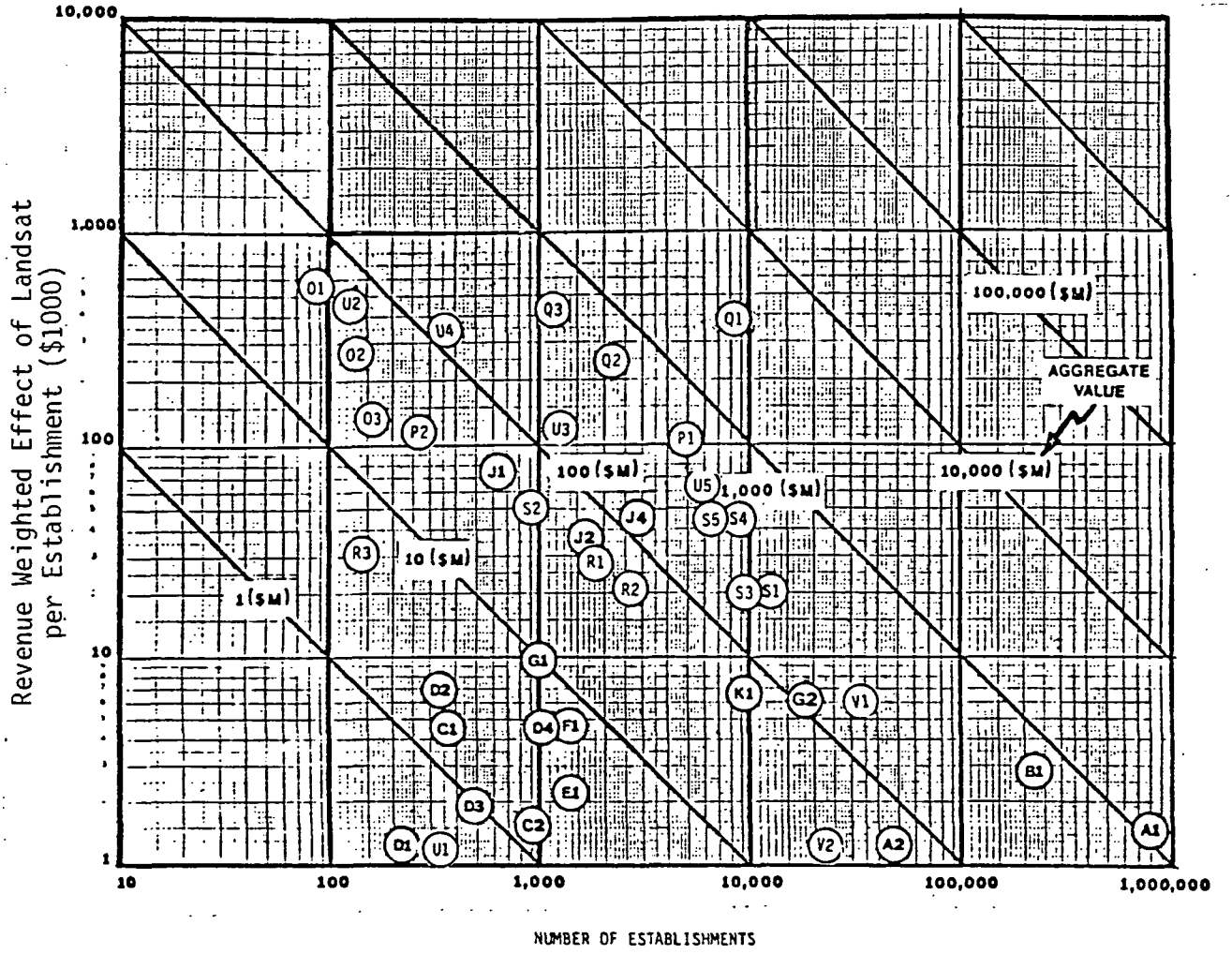
*Less than 1%.

Table 4-2 (cont.)

SUMMARY OF BUSINESS PROFILE ANALYSIS - LANDSAT

INDUSTRY	BUSINESS TYPE	PERCENT OF REMOTELY SENSIBLE INFORMATION AVAILABLE FROM LANDSAT				REVENUE WEIGHTED EFFECT OF LANDSAT ($ MILLIONS)				AVERAGE REVENUE EFFECT OF LANDSAT PER ESTABLISHMENT ($ MILLIONS)			
		1980	1982	1990	1995	1980	1982	1990	1995	1980	1982	1990	1995
Management and Consulting Services	City Planners	*	*	70%	100%	*	*	120	170	*	*	.1	.2
	Site Locators	*	*	100%	100%	*	*	120	120	*	*	.3	.3
Services N.E.C.	Weather Forecasters	*	*	*	*	*	*	*	*	*	*	*	*

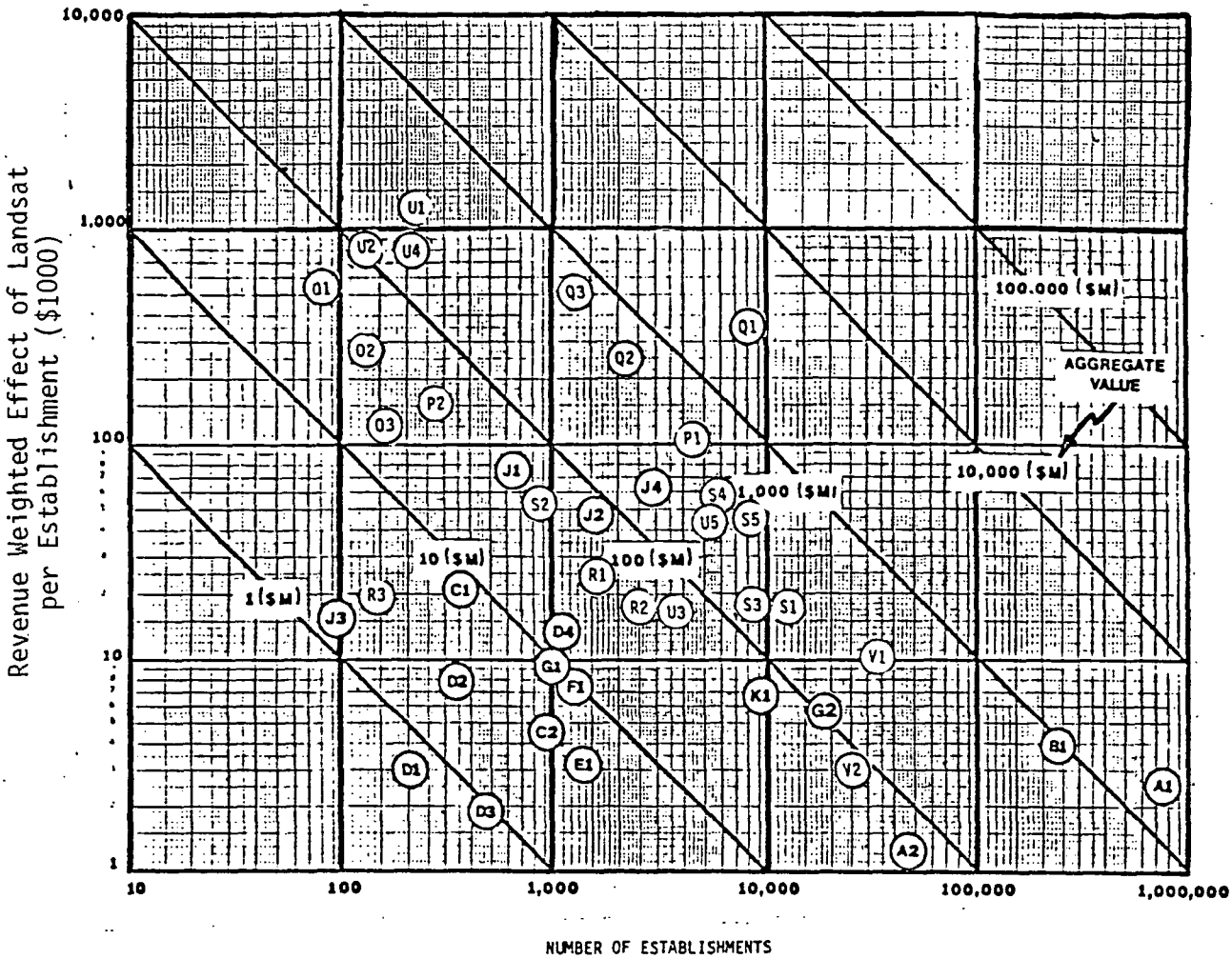
*Less than 1%.



A1	FIELD CROPS	D2	FERTILIZER AP. (AFTER PLANTING)	G2	FOREST FARMS	J4	CIVIL ENGINEERING
A2	TREE CROPS	D3	WEED CONTROL	H1	WILDLIFE MANAGEMENT	K1	ARCHITECTURAL
B1	LIVESTOCK	D4	INSECTS & DISEASE	I1	FISHING	L1	LAND SURVEYING
C1	PLOWING	E1	HARVESTING	J1	SOILS ENGINEERING	M1	CITY PLANNERS
C2	FERTILIZER AP.	F1	LANDSCAPE	J2	SANITARY ENGINEERING	M2	SITE LOCATORS
D1	PLANTING	G1	FOREST SERVICES	J3	MINING ENGINEERING	N1	WEATHER FORECASTERS

O1	IRON ORES	Q3	OIL & GAS EXPLORATION SERVICES	S3	WATER, SEWER, PIPELINE, COMMUNICATION, & POWER LINE CONSTRUCTION CONTRACTORS	U3	GAS & OTHER COMBINED
O2	COPPER ORES	R1	CRUSHED & BROKEN STONE	S4	HEAVY CONSTRUCTION CONTRACTORS, N.E.C.	U4	COMBINATION UTILITIES, N.E.C.
O3	METAL MINING SERVICES	R2	SAND & GRAVEL	S5	GENERAL CONTRACTORS--INDUSTRIAL BUILDINGS & WAREHOUSES	U5	WATER SUPPLY, SANITARY SERVICES, & IRRIGATION SERVICES
P1	BITUMINOUS COAL & LIGNITE	R3	NONMETALLIC MINERALS SERVICES	T1	WATER TRANSPORTATION	V1	INSURANCE AGENTS, BROKERS, & SERVICE
P2	BITUMINOUS COAL & LIGNITE MINING SERVICES	S1	HIGHWAY & STREET CONSTRUCTION CONTRACTORS	U1	ELECTRIC SERVICES	V2	SUBDIVIDERS & DEVELOPERS
Q1	CRUDE PETROLEUM & NATURAL GAS	S2	BRIDGE, TUNNEL, & ELEVATED HIGHWAY CONSTRUCTION CONTRACTORS	U2	NATURAL GAS TRANSMISSION & DISTRIBUTION		
Q2	DRILLING OIL & GAS WELLS						

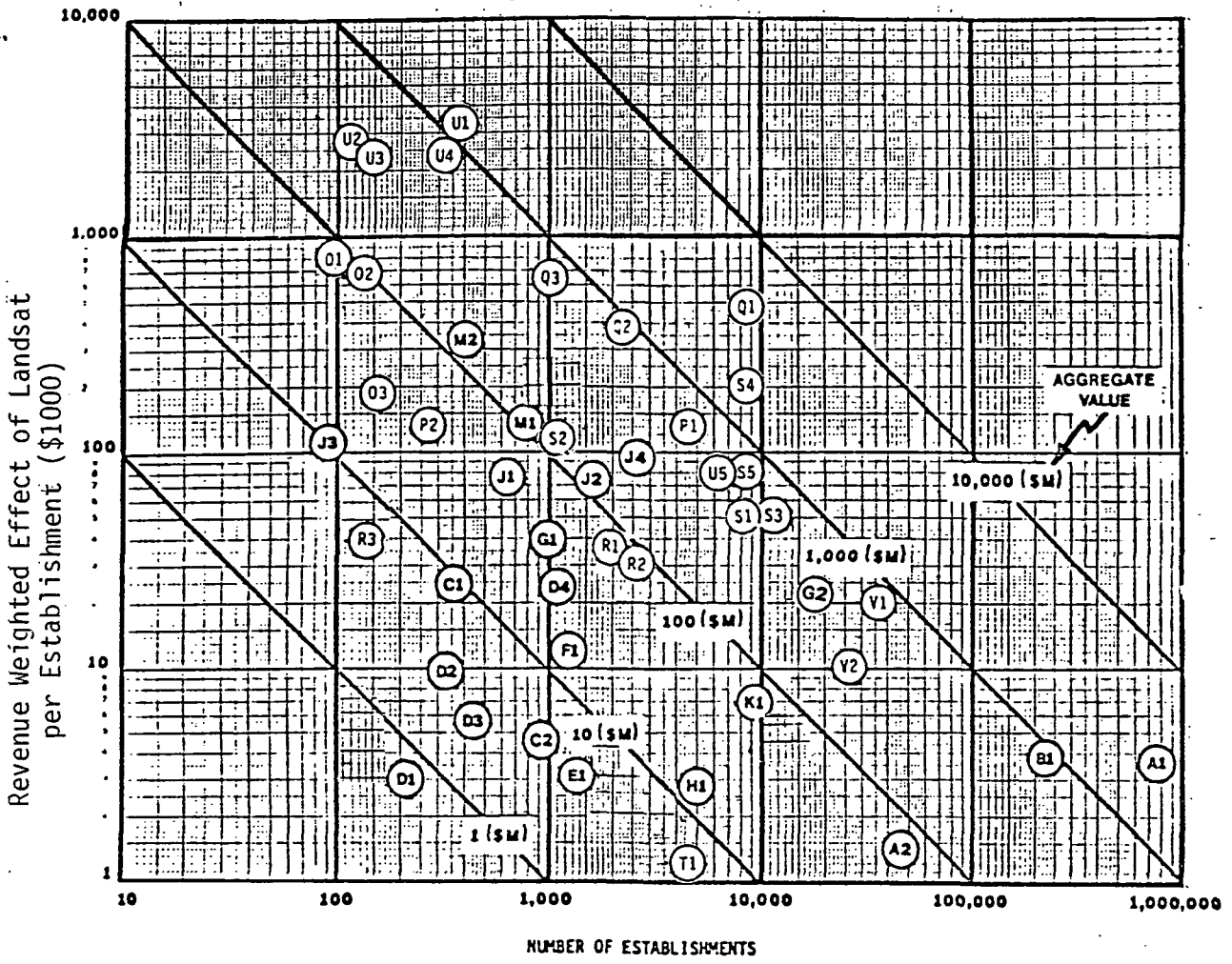
FIGURE 4-6. COMPARISON OF LANDSAT POTENTIAL FOR PROFILED BUSINESS (1980)



A1	FIELD CROPS	O2	FERTILIZER AP. (AFTER PLANTING)	G2	FOREST FARMS	J4	CIVIL ENGINEERING
A2	TREE CROPS	O3	WEED CONTROL	H1	WILDLIFE MANAGEMENT	K1	ARCHITECTURAL
B1	LIVESTOCK	D4	INSECTS & DISEASE	I1	FISHING	L1	LAND SURVEYING
C1	PLOWING	E1	HARVESTING	J1	SOILS ENGINEERING	M1	CITY PLANNERS
C2	FERTILIZER AP.	F1	LANDSCAPE	J2	SANITARY ENGINEERING	M2	SITE LOCATORS
D1	PLANTING	G1	FOREST SERVICES	J3	MINING ENGINEERING	N1	WEATHER FORECASTERS

O1	IRON ORES	Q3	OIL & GAS EXPLORATION SERVICES	S3	WATER, SEWER, PIPELINE, COMMUNICATION, & POWER LINE CONSTRUCTION CONTRACTORS	U3	GAS & OTHER COMBINED
O2	COPPER ORES	R1	CRUSHED & BROKEN STONE	S4	HEAVY CONSTRUCTION CONTRACTORS, N.E.C.	U4	COMBINATION UTILITIES, N.E.C.
O3	METAL MINING SERVICES	R2	SAND & GRAVEL	S5	GENERAL CONTRACTORS--INDUSTRIAL BUILDINGS & WAREHOUSES	U5	WATER SUPPLY, SANITARY SERVICES, & IRRIGATION SERVICES
P1	BITUMINOUS COAL & LIGNITE	R3	NONMETALLIC MINERALS SERVICES	T1	WATER TRANSPORTATION	V1	INSURANCE AGENTS, BROKERS, & SERVICE
P2	BITUMINOUS COAL & LIGNITE MINING SERVICES	S1	HIGHWAY & STREET CONSTRUCTION CONTRACTORS	U1	ELECTRIC SERVICES	V2	SUBDIVIDERS & DEVELOPERS
Q1	CRUDE PETROLEUM & NATURAL GAS	S2	BRIDGE, TUNNEL, & ELEVATED HIGHWAY CONSTRUCTION CONTRACTORS	U2	NATURAL GAS TRANSMISSION & DISTRIBUTION		
Q2	DRILLING OIL & GAS WELLS						

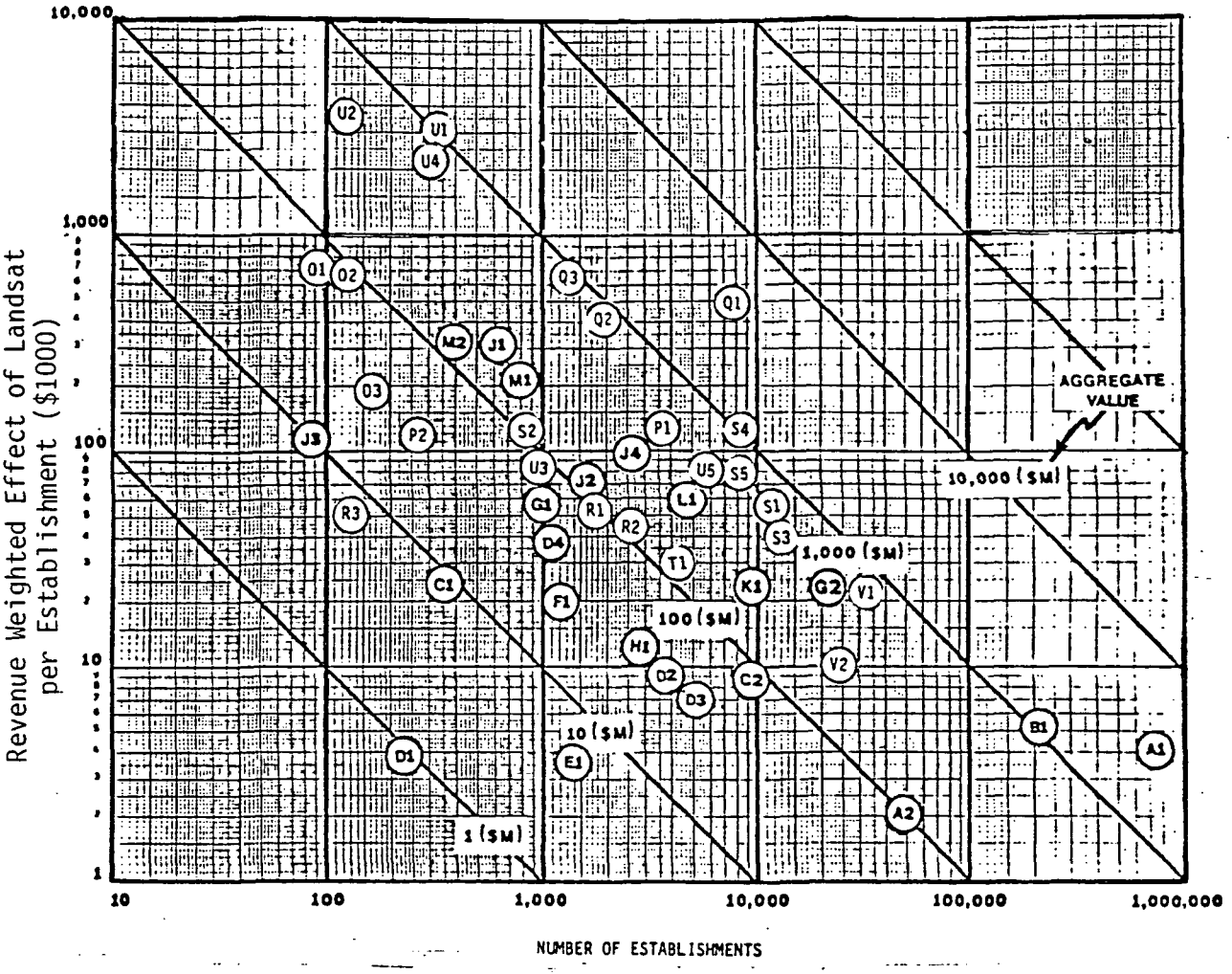
FIGURE 4.7. COMPARISON OF LANDSAT POTENTIAL FOR PROFILED BUSINESS (1982)



A1	FIELD CROPS	D2	FERTILIZER AP. (AFTER PLANTING)	G2	FOREST FARMS	J4	CIVIL ENGINEERING
A2	TREE CROPS	D3	WEED CONTROL	H1	WILDLIFE MANAGEMENT	K1	ARCHITECTURAL
B1	LIVESTOCK	D4	INSECTS & DISEASE	I1	FISHING	L1	LAND SURVEYING
C1	PLOWING	E1	HARVESTING	J1	SOILS ENGINEERING	M1	CITY PLANNERS
C2	FERTILIZER AP.	F1	LANDSCAPE	J2	SANITARY ENGINEERING	M2	SITE LOCATORS
D1	PLANTING	G1	FOREST SERVICES	J3	MINING ENGINEERING	N1	WEATHER FORECASTERS

O1	IRON ORES	Q3	OIL & GAS EXPLORATION SERVICES	S3	WATER, SEWER, PIPELINE, COMMUNICATION, & POWER LINE CONSTRUCTION CONTRACTORS	U3	GAS & OTHER COMBINED
O2	COPPER ORES	R1	CRUSHED & BROKEN STONE	S4	HEAVY CONSTRUCTION CONTRACTORS, N.E.C.	U4	COMBINATION UTILITIES, N.E.C.
O3	METAL MINING SERVICES	R2	SAND & GRAVEL	S5	GENERAL CONTRACTORS--INDUSTRIAL BUILDINGS & WAREHOUSES	U5	WATER SUPPLY, SANITARY SERVICES, & IRRIGATION SERVICES
P1	BITUMINOUS COAL & LIGNITE	R3	NONMETALLIC MINERALS SERVICES	T1	WATER TRANSPORTATION	V1	INSURANCE AGENTS, BROKERS, & SERVICE
P2	BITUMINOUS COAL & LIGNITE MINING SERVICES	S1	HIGHWAY & STREET CONSTRUCTION CONTRACTORS	U1	ELECTRIC SERVICES	V2	SUBDIVIDERS & DEVELOPERS
Q1	CRUDE PETROLEUM & NATURAL GAS	S2	BRIDGE, TUNNEL, & ELEVATED HIGHWAY CONSTRUCTION CONTRACTORS	U2	NATURAL GAS TRANSMISSION & DISTRIBUTION		
Q2	DRILLING OIL & GAS WELLS						

FIGURE 4-8. COMPARISON OF LANDSAT POTENTIAL FOR PROFILED BUSINESS (1990)



A1	FIELD CROPS	D2	FERTILIZER AP. (AFTER PLANTING)	G2	FOREST FARMS	J4	CIVIL ENGINEERING
A2	TREE CROPS	D3	WEED CONTROL	H1	WILDLIFE MANAGEMENT	K1	ARCHITECTURAL
B1	LIVESTOCK	D4	INSECTS & DISEASE	I1	FISHING	L1	LAND SURVEYING
C1	PLOWING	E1	HARVESTING	J1	SOILS ENGINEERING	M1	CITY PLANNERS
C2	FERTILIZER AP.	F1	LANDSCAPE	J2	SANITARY ENGINEERING	M2	SITE LOCATORS
D1	PLANTING	G1	FOREST SERVICES	J3	MINING ENGINEERING	N1	WEATHER FORECASTERS

O1	IRON ORES	Q3	OIL & GAS EXPLORATION SERVICES	S3	WATER, SEWER, PIPELINE, COMMUNICATION, & POWER LINE CONSTRUCTION CONTRACTORS	U3	GAS & OTHER COMBINED
O2	COPPER ORES	R1	CRUSHED & BROKEN STONE	S4	HEAVY CONSTRUCTION CONTRACTORS, N.E.C.	U4	COMBINATION UTILITIES, N.E.C.
O3	METAL MINING SERVICES	R2	SAND & GRAVEL	S5	GENERAL CONTRACTORS--INDUSTRIAL BUILDINGS & WAREHOUSES	U5	WATER SUPPLY, SANITARY SERVICES, & IRRIGATION SERVICES
P1	BITUMINOUS COAL & LIGNITE	R3	NONMETALLIC MINERALS SERVICES	T1	WATER TRANSPORTATION	V1	INSURANCE AGENTS, BROKERS, & SERVICE
P2	BITUMINOUS COAL & LIGNITE MINING SERVICES	S1	HIGHWAY & STREET CONSTRUCTION CONTRACTORS	U1	ELECTRIC SERVICES	V2	SUBDIVIDERS & DEVELOPERS
Q1	CRUDE PETROLEUM & NATURAL GAS	S2	BRIDGE, TUNNEL, & ELEVATED HIGHWAY CONSTRUCTION CONTRACTORS	U2	NATURAL GAS TRANSMISSION & DISTRIBUTION		
Q2	DRILLING OIL & GAS WELLS						

FIGURE 4-9. COMPARISON OF LANDSAT POTENTIAL FOR PROFILED BUSINESS (1995)

4.5.1 AGRICULTURE, FORESTRY, AND FISHING DIVISION

The agribusinesses are predominantly made up of individual farms with various small service companies providing them support. As an industrial group they generate a large amount of revenue, however, individual establishments are, on the average, relatively small.

Remote sensing, particularly Landsat, has been used in agricultural applications by the government sector for many years. It has been demonstrated to be a useful tool in satisfying agricultural user needs. However, the private sector has only put it to limited use.

This study indicates there are definite informational needs that could be satisfied by Landsat, to some extent now, and with greater assurance in the future. But, with the large number of individual establishments in the agribusiness industry, with their limited monetary resources per establishment, they probably will be unable to afford the expense of performing Landsat analysis on their own. Thus, the agribusinesses would be best served by a digital analyses service industry specializing in Landsat-derived information that could be used by all segments of the agricultural farming community.

The forest industries, as grouped in this study, are dominated by the tree farm sector, which includes the large land holdings of the several forest products industries, and numerous smaller tree farm operations. This industry, especially the large companies, have used remote sensing for many years, but have considered Landsat only recently. A primary user is St. Regis Corp. which in recent years has worked with NASA in an APT Project developing the use of Landsat information in a geographic information system.

The forest industry appears to be a good candidate for using Landsat in the near future. The larger companies already have some remote sensing experience, the information needs, and the capital to make them ideal candidates for technology transfer. The many smaller establishments also have an apparent need, but lack significant capital per establishment and would be better served by a digital analysis service business.

The fishing industry appears to have very little informational needs that can be satisfied by Landsat for anytime in the near future.

4.5.2 MINING

The industries classified in the mining division are generally made up of the largest businesses covered in this study. Mining can be generally categorized into 3 main indutries: oil and natural gas, coal, and ores.

The dominant industry in the mining division is made up of the oil and gas businesses with their associated service companies. This industry has been the largest single user of Landsat data in the private sector. Initially most of the industry analyzed Landsat using primarily conventional image interpretation techniques. Presently, many of the larger corporations are purchasing digital analysis systems to perform more sophisticated analysis techniques in their search for oil and gas deposits.

The second category is the coal industry which is becoming an increasingly important segment of the private sector. The coal industry has not fully utilized the potential of Landsat in satisfying its present and future needs. In the near future, as strip mining increases, these companies will not only require remotely sensed information for exploration, but will have an increasing requirement to monitor their impact on the environment. This industry should be utilizing more Landsat-derived information during the Landsat D time period, and thus appears to be a good candidate for technology transfer efforts.

The third category is made up of several mineral ore companies that are dominated by the iron and copper ore businesses. This industry, like coal, has utilized Landsat data to some degree in their exploration work, but with environmental requirements becoming increasingly more important, will rely more heavily on remotely sensed information in the future. This industry also appears to be a potential candidate for technology transfer efforts of new Landsat derived information for environmental monitoring, as well as new exploration techniques.

The entire mining division, though dominated by a few large corporations with sufficient capital to purchase their own digital analysis systems, has numerous intermediate-- and small--size companies (especially mining service companies) with needs for Landsat-derived information. These smaller companies would benefit from a digital analysis service industry that specializes in geological and environmental applications.

4.5.3 CONSTRUCTION

The construction division is comprised of a variety of construction companies building everything from highways and pipelines to nuclear power plants. Most of the industries in this division have not utilized Landsat technology to date. There are a few very large firms which could invest in their own Landsat analysis capability, but are unwilling to do so until resolution and reliability improve in future Landsat systems. However, most of the industry is intermediate and smaller companies that could better be served by a digital analysis service industry.

This industry appears to have potential for technology transfer efforts in the post Landsat D era, using the higher resolution TM, because of the increasing requirements for environmental impact analyses on large construction activities. In addition, Landsat D could play a potential role in right-of-way assessments, and site location and evaluation.

4.5.4 MANUFACTURING

The manufacturing division was determined to have no significant requirements for Landsat applications.

4.5.5 TRANSPORTATION, COMMUNICATIONS, ELECTRIC, GAS, AND SANITARY SERVICES

This division is made up of a diverse group of industries. Some, such as the electric and gas utilities have potential for significant uses of Landsat D technology in the coming years. Also, the water supply, sanitary services and irrigation service businesses appear to have moderate requirements, that could utilize Landsat technology, primarily in water resource management. However, the transportation and communications

business do not appear to have significant applicational need for Landsat data in the near future.

The gas and electric utilities companies, especially those in the western U.S., are very large and have the potential to utilize Landsat in a variety of applications. Several of these utilities have large land holdings which require management. In addition, the expansion in utility construction will require new site location and evaluation for conventional, nuclear and hydroelectric power plants, right-of-way selection for pipelines and power lines, environmental impact assessments, and water resource management for the hydroelectric sites. This variety of applications for a few very large utilities makes this industry a good candidate for Landsat technology.

4.5.6 WHOLESALE TRADE

The wholesale trade division was determined to have no industries with significant requirements for Landsat technology.

4.5.7 RETAIL TRADE

The retail trade division was determined to have no industries that could have significant Landsat applications.

4.5.8 FINANCE, INSURANCE, AND REAL ESTATE

This diverse division has a few businesses, primarily in real estate, with potential for some Landsat technology utilization. The applications in real estate are primarily in the planning and development of large real estate projects. Because many of the individual establishments are relatively small, the remote sensing service industry might best serve this group.

The finance and insurance industries are quite fragmented and have minimal need for Landsat technology. One exception exists in the area of catastrophic event damage assessment, although these activities are generally performed by government agencies.

4.5.9 SERVICES

This very diverse and fragmented industry has the potential for Landsat technology in the engineering, architectural, land surveying, and selected management and consulting services. Most of the businesses in these groups are relatively small but their combined total revenues represent a significant monetary amount that would be affected by Landsat technology.

The services mentioned above have experience in conventional remote sensing techniques, however, the Landsat technology has had only limited use. One reason for not using Landsat is the expense in performing digital image analyses. Another is the need for higher resolution (i.e., Landsat D TM) data which would more accurately meet their requirements. This industry would best be served by a digital analysis service company which specialized in the engineering, architectural, and land surveying activities.

5.0 ASSESSMENT OF THE POTENTIAL U.S. INDUSTRY ROLE IN THE FOREIGN LANDSAT MARKET

5.0 ASSESSMENT OF THE POTENTIAL U.S. INDUSTRY ROLE IN THE FOREIGN LANDSAT MARKET

5.1 INTRODUCTION

This section provides an assessment of the degree to which remote sensing technology, primarily Landsat, can be utilized in solving world problems; and the extent that this can stimulate the domestic service industry in the foreign sector. Three specific studies are presented in this section to provide a variety of information which can be used to project the potential role for the domestic service industry. A synopsis of the remote sensing program of U.S. Agency for International Development (USAID) appears in Section 5.2, and case histories of the foreign market experience of two remote sensing service businesses, one foreign and one domestic, are given in Sections 5.3 and 5.4.

5.2 US/AID REMOTE SENSING PROGRAM

Space exploration has driven the development of technology useful in gathering vital data on natural resources monitoring, such as crop statistics, irrigation data, natural hazards, rates of deforestation, etc. Satellite remote sensing provides a synoptic view for a more accurate look at changing resources. Visual interpretation techniques are now in use around the world for assisting managers in better understanding patterns of resource use. The philosophy at US/AID is to foster wider use of this new technology and to stimulate its evolution into a fully integrated resource information system for economic development.

To help meet resource data needs for economic development, US/AID has been actively promoting the internationalization of remote sensing technology since 1971. United States economic and technical assistance has been provided to stimulate the transfer of people and ideas across a broad front of applications and to establish an integrated infrastructure of facilities and trained personnel.

The basic elements of the US/AID remote sensing program include: 1) integrated use of aerial photography and Landsat imagery with field data to assist project-oriented natural resource investigations; 2) assistance to developing countries in form of U.S. experts, training and demonstrations; 3) financial assistance in the form of project grants, support for formal education in U.S. universities, on-the-job training in developing countries, and support for the creation of national and regional remote sensing centers; and, 4) financial and technical support for cooperative projects between U.S. institutions/industries and developing country counterparts. See Table 5-1 for a synopsis of U.S./AID Remote Sensing Program Activities.

US/AID began its remote sensing dissemination program in 1971, however, it was not until the advent of Landsat imagery that the usefulness of satellite remote sensing as a tool to assist in global economic development became apparent. This led to US/AID sponsoring the first three International seminars at the EROS Data Center in Sioux Falls, South Dakota, and subsequently has sponsored international symposia, training seminars and demonstration projects. Two major population census projects were conducted in Kenya and Bolivia, the latter resulting in an International Symposium on Remote Sensing and Demography in La Paz. US/AID also sponsored programs involving the participation of the Environmental Research Institute of Michigan and the Remote Sensing Institute of South Dakota State University have resulted in projects and training carried out in more than 30 countries in South America, Africa, the Near East, and Asia. In addition, using a communications satellite, US/AID and NASA have transmitted three films to planners and heads of state in 27 developing countries. These films demonstrated how Landsat data could be used to monitor natural resources.

The success of these efforts has led to the creation of both national and regional remote sensing centers which focus their activities on regional resource inventory and management. These centers were built to provide complete facilities for training, photo and image processng and reproduction, field support, interpretation, and applications. Two regional centers are operating in Nairobi, Kenya and Ouagadougou, Upper Volta and a third is planned for Bangkok, Thailand. Two additional centers are being proposed for Latin America and one in the Near East.

Table 5-1. UNITED STATED AGENCY FOR INTERNATIONAL DEVELOPMENT REMOTE SENSING PROGRAM

GRANTS	PROJECTS	CENTERS	TRAINING
Bangladesh: map areas for third rice crop	Costa Rica: forest survey	Regional:	EROS Data Center
Bolivai: explore iron formations	Bolivia: population census	Nairobi, Kenya	
Cameroon: develop resource management techniques	Senegal: resource inventory	Ouagadougou, Upper Volta	South Dakota State Univ.
Chile: inventory resources	Upper Volta, Togo, Benin: Onchocerciasis (river blindness) - free area survey	Planned:	Univ. of New Mexico
Haiti: measure sugar cane	Morocco: geological mapping	Bangkok, Thailand	Argentina
Lesotho: investigate snow-fall and drainage patterns	Mali: range management	Cairo, Egypt	Peru
Pakistan: map river sediment loads for new port location	Kenya: population census (land cover & use)	2 planned in Latin America	Botswana
Peru: identify and map aguaje palm	Bangladesh: weather satellite station	National:	Senegal
Phillipines: assist development of Mindoro Island	Dominican Republic, Jamaica, Costa Rica, Ecuador, Bolivia, Morocco, Thailand, Philippines, and Indonesia: agricultural crop estimates	Cairo, Egypt	Sudan
Sri Lanka: measure rice crop		Tunis, Tunisia	Nepal
Swaziland: locate ground water		Kinshasa, Zaire	
Thailand: survey agriculture		Bangkok, Thailand	
Zaire: provide map base		Planned:	
		Younde, Cameroon	
		Damascus, Syria	
		Katmandu, Nepal	

The primary role of each of the centers is to assist individual countries in keeping abreast of technical developments, to provide training at all levels, and to help develop new techniques using remote sensing data for solving problems of regional concern.

US/AID's future activities are based on the use of Landsat data to assist developing country resource agencies in identifying appropriate applications and analytical processes for use to address their most urgent problems.

Regional resource needs that have already been identified include: 1) deforestation and desertification survey techniques; 2) coastal zone food resources; 3) mineral resource surveys for fertilizer production; 4) geothermal exploration techniques; 5) appropriate and economical digital image processing systems and resource information systems; 6) improved cartographic techniques; and 7) crop production monitoring and estimation.

US/AID's goals for the future are to continue to integrate aerial and satel lite acquired data to satisfy basic human needs of food and fiber production, water supply management, improved shelter, and energy use; and to further the modernization of developing nations.

Under US/AID's present operating plan the private sector is very much involved in the program and the majority of the funding eventually goes to the U.S. private industry. Once US/AID representatives have obtained an agreement with a country to provide aid in assisting the development a remote sensing capability, a competitive bid contract is then awarded to industry to provide the personnel and equipment necessary to establish a center or support a project. Presently there are several U.S. firms providing personnel for training and technology transfer, as well as the necessary equipment to support the various projects. Some of the companies currently contracted to US/AID are Spectral Data Corporation, Environmental Research Institute of Michigan, EARTHSAT Corporation and Technicolor Corporation. Presently, about one million dollars per year are available to the private sector to support direct remote sensing programs. It is estimated that over the next 5 years approximately $60 million will be available for all US/AID projects, with the majority of it

going to U.S. industries. However, only about $5 million (or $1 million per year) will be directly related to Landsat remote sensing programs.

Most of the competitive contracts are for 1-2 years and call for a 4-5 person staff with conventional support equipment to provide the necessary training of host country personnel. Present US/AID programs do not require sophisticated image/digital analysis systems/equipment, but utilize more conventional photo analysis equipment. This is primarily due to lack of skilled maintenance personnel, spare parts and costs to keep computer systems operating.

As mentioned above, all US/AID remote sensing projects focus on using Landsat as the prime imagery. Representatives of foreign countries have shown a great interest in using Landsat, and US/AID is having success involving many lesser developed countries in the program. However, there is concern that any delays in launching Landsat-D could be very detrimental to the entire AID program; and much of what the U.S. has accomplished could be relinquished to the Russians (Soyez program) and French (SPOT program). Since most of today's US/AID contracts are primarily involved in training and demonstration projects, there is not too much concern about the lack of Landsat data. However, if the situation should continue for more than 1-2 years, it would be disasterous to the AID program and would affect contract money that would be available to U.S. industries.

U.S. industries are currently very interested in participating in US/AID contracts with from 3 to 15 companies usually competing for each contract. US/AID officials are confident that U.S. industry will continue to show interest in these contracts even with the changing political climates and current unrest in the world. The key to the future success of the whole program appears to be the successful launch of Landsat D within the next two years.

5.3 CASE HISTORY OF A FOREIGN-BASED, REMOTE SENSING SERVICE BUSINESS.

This section presents an examination of the foreign market experiences of a foreign-based remote sensing (including Landsat) service business. The information obtained from this examination will provide a better understanding of the foreign market for Landsat-derived products and services

and the potential for U.S. service industry involvement. The foreign firm selected for case study was ITALECO spa., the largest private industry user of Landsat in Italy and one of the largest in Europe.

ITALECO spa. is the high-technology arm of a much larger firm ITALSTAT spa. ITALSTAT is an architectural and engineering (A&E) establishment that does approximately one billion dollars of business yearly. ITALECO's charter is to support ITALSTAT in the development and application of advanced methodologies, algorithms, and tools for optimizing subsequent A & E design activities. For example, ITALECO might support ITALSTAT by forecasting the effect of constructing a new reservoir upon a particular geographic area; in terms of projected agricultural activity, environmental impact, and standard of living.

A major key to ITALECO's business is a knowledge and understanding of surface cover information. In this regard, ITALECO has long made abundant use of aerial photography. Moreover, in 1979, following the installation of the Landsat receiving station near Rome, ITALECO started to invest significantly in the exploitation of satellite remote sensing by virtue of its promise of becoming a primary survey tool. Market research by ITALECO indicated that the majority of the European interest in Landsat, as of 1976, was in research and development. This is still the case in 1981. Figure 5-1 shows the location of major Landsat research projects in Europe.

Conditions in Europe make it difficult for an industrial concern to significantly penetrate the market for Landsat R & D activities, because R&D is institutionally dominated by academia and research institutions. Consequently, ITALECO has decided to focus their Landsat efforts in the custom production of operationally - oriented products, specifically, along three lines of endeavor:

(1) Generation of products in which conventional ground or remote methods could be replaced by LANDSAT. Land use mapping appeared particularly attractive because Italy's most recent comprehensive mapping was performed in 1960.

(2) Generation of products, where LANDSAT would be used to augment the quality achieved by conventional ground and remote methods.

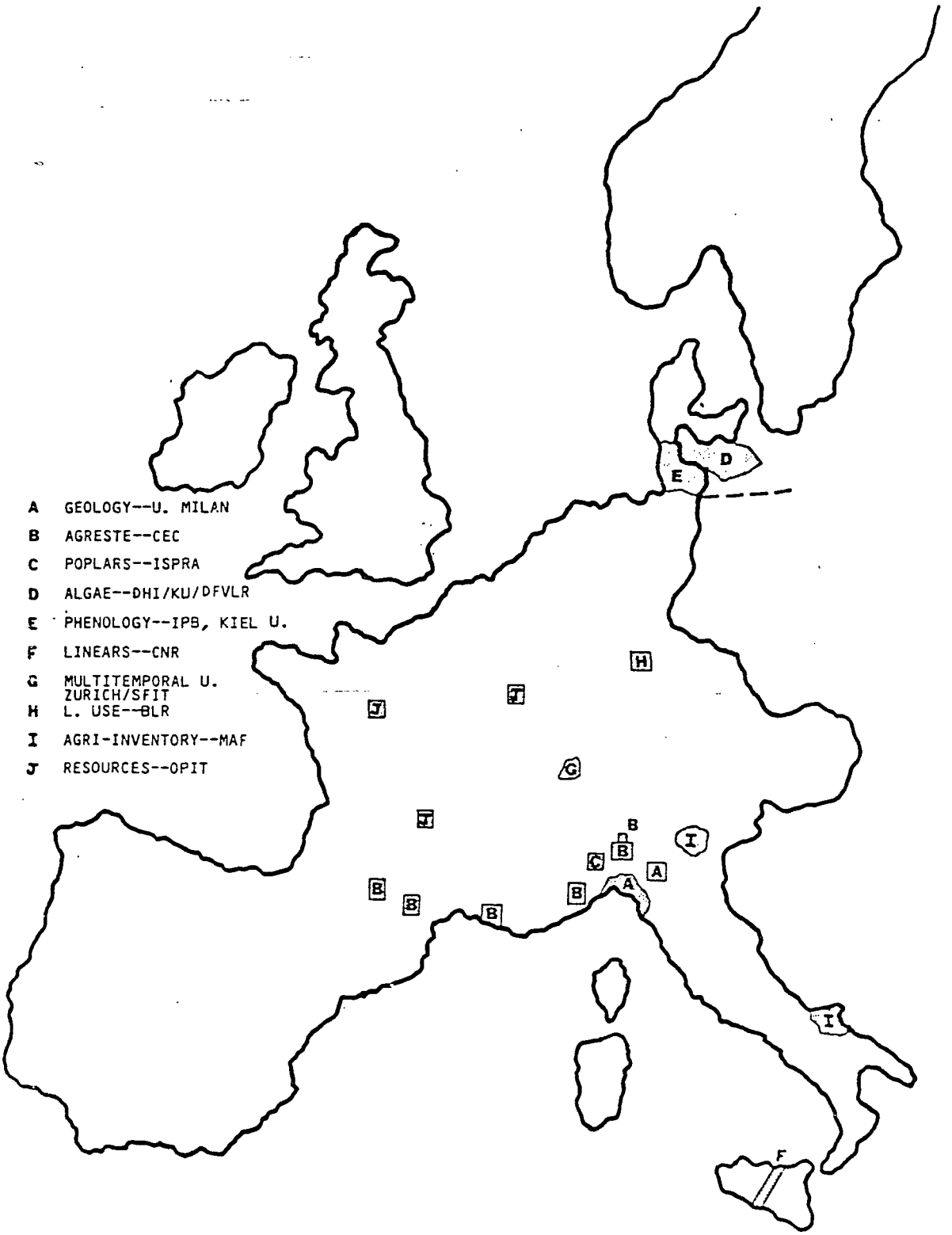


Figure 5-1. Major Research Projects Using Landsat

(3) Solutions to problems by attempting to reduce the cost of classical survey efforts through use of LANDSAT.

Table 5-2 shows a selection of ITALECO contractual tasks which have involved the use of Landsat.

ITALECO's Landsat commercialization efforts can be summarized as follows:

- o It has yet to recoup its investment in Landsat equipment, training, expert consultation. The principal reason for this has been the absence of good "how to" procedures and rules for using Landsat. This lack has forced ITALECO to experiment at great cost in time and money with many methods of using Landsat e.g., computer analysis, manual interpretation, image combinations, and integration of various information sources.

- o It has discontinued the generation of products from Landsat data alone except for specific use in developing nations, where conventional coverage is not available, too costly, or overly time consuming to collect. In more developed nations the accuracy afforded by products from Landsat information alone does not generally meet the needs of ITALECO's customers.

- o ITALECO is still in the business of producing classical products, e.g., land use maps, by combining Landsat with various other sources of information. Here Landsat works well, not as the primary tool but as an important adjunt. However, the market for Landuse maps and related products, which promised to be very strong in the mid-seventies, has not materialized in a significant way. Most customers are interested in specific problem solving applications.

- o ITALECO's largest market, currently and they believe in the future, is the use of Landsat in end-to-end problem solving applications.

- o Despite uncertainties about the future continuity of service, ITALECO plans to continue to use and market landsat and is looking

Table 5-2. PRINCIPAL WORKS BY ITALECO USING LANDSAT

GENERAL LAND COVER

CUSTOMER	PRODUCT	DATE	METHOD
REGION BASILICATA	THEMATIC MAP 10,000 KM^2	1977	1
REGION BASILICATA	THEMATIC MAP 10,000 KM^2	1977	2
REGION CALABRIA	THEMATIC MAP 5,000 KM^2	1977	2
REGION EMILIA-ROMAGNA	THEMATIC MAP 2,000 KM^2	1978	2
REGION LAZIO	THEMATIC MAP 6,000 KM^2	1978	1
REGION CAMPANIA	THEMATIC MAP BENIVENTO PROVINCE 2,000 KM^2	1979	2
ITALAIRPORTS	THEMATIC MAP S. COAST GUATEMALA	1980	1

SPECIFIC THEME DEPICTION

REGION LOMBARDY	THEMATIC MAP WHEAT/CORN/FORAGE, 1,000 KM^2	1978	2
REGION EMILIA-ROMAGNA	THEMATIC MAP WHEAT/SUGARBEETS	1979	1
NATURAL RESOURCES COUNCIL	HYDROGEOLOGIC FEATURES BAUCI, NEGERIA	1979	1
AGRICULTURE MINISTRY	NIGER RIVER INUNDATIONS	1979	1
ITALAIRPORT	HYDROGEOLOGIC LINEAMENTS S. COAST GUATEMALA	1980	1

1 = LANDSAT ONLY

2 = LANDSAT PLUS OTHER DATA SOURCES

Table 5-2. PRINCIPAL WORKS BY ITALECO USING LANDSAT (cont.)

CUSTOMER	PRODUCT	DATE	METHOD
LOMBARDY REGION	INVENTORY WHEAT/CORN/FORAGE	1978	2
REGION LAZIO	DEVELOPMENT MODEL	1979	2
AGRICULTURE MINISTRY	INVENTORY WHEAT P. OF FOGGIA 4, 500 KM^2	1979	2
AGRICULTURE MINISTRY	WATER RESOURCES CONTENT OF SNOW COVER VAL D' AOSTA 5,000 KM^2	1980	1
PUBLIC WORKS MINISTRY	STRUCTURAL STABILITY OF ROADBEARING SOILS	1980	2
TRANSPORTATION MINISTRY	STRUCTURAL STABILITY OF RAILBEARING SOILS	1980	2
REGION VENETO	AGRICULTURAL LAND CAPABILITY 3,000 KM^2 P. OF BELLEMO	1980	2

1 = LANDSAT ONLY

2 = LANDSAT PLUS OTHER DATA SOURCES

forward to improved Landsat-type platforms, such as Landsat D and the french satellite SPOT.

Implication for the role of U.S. industry which can be drawn from ITALECO experiences are:

(1) The potential for U.S. private industry involvement in support of research and development activities is minimal in Europe due to institutional constraints.

(2) The market for Landsat-based map and inventory products, once thought to have increasing demand within Europe, has not developed as expected and thus does not appear to be an attractive avenue for U.S. industry involvement in the foreign Landsat market.

(3) The only significant avenue for U.S. industry involvement appears to be the application of Landsat to the solution of operational problems. In this light, the major role seen for U.S. industry is in support of foreign industry and governments using Landsat technology in support of end-to-end problem solving activities.

(4) Foreign industry has a desire to develop a high degree of self-sufficiency in satellite remote sensing. The major problem it faces is the lack of good equipment, procedures and models required for the utilization of Landsat. Consequently, there is a significant market for U.S. developed Landsat analysis equipment, procedures, and models. There is particular interest in equipment and techniques for combining Landsat information with other forms of data.

5.4 CASE HISTORY OF THE FOREIGN ACTIVITIES OF A DOMESTIC REMOTE SENSING SERVICE BUSINESS.

In this section is an examination of the foreign market experiences of a domestic remote sensing service business. The business utilized for this examination is ECOsystems International, Inc., which has been providing foreign concerns, including ITALECO, with technical support in the development of operational Landsat capabilities.

In recent years ECOsystems has pursued approximately one third of its remote sensing-related work in the foreign market place. Some of ECOsystems key foreign contractual experiences related to remote sensing are summarized in Table 5-3.

ECOsystems major emphasis in the foreign market is technology transfer, i.e., adaption of U.S. developed technologies to the solution of operational problems faced by foreign industry and government. Their experiences support the contention that many foreign concerns are interested in developing a measure of self sufficiency with regards to satellite remote sensing. ECOsystems has been able to capitalize on this desire by providing foreign customers with the models, equipment and "how-to" procedures they require to use Landsat.

For example, in the area of model development they were commissioned to develop a computerized hydrologic model for the region of Tuscany in Italy. This required the delivery of a digital computer program plus complete model set-up and operations documentation, including detailed documentation of procedures for analyzing Landsat data for this particular application.

As mentioned above, their experiences also support the contention that there is a foreign demand for techniques for combining Landsat with other forms of data. Their experience has shown that the land cover classification and mapping capabilities provided by Landsat alone are insufficient for most foreign customer needs. Figure 5-2 shows typical Landsat performances achieved by ECOsystems with and without the use of supplemental data, and their relationship to the performance required (i.e., % accuracy) by most foreign customers.

ECOsystems has been able to capitalize on this demand for data combination techniques through the development of special procedures and low cost optical equipment for interpreting, scaling and overlaying Landsat and other data types. Both the procedures and equipment have been successfully marketed in Italy.

Most of this company's recent activities within the foreign market have focused on the adaption of Landsat technology to the solution of a specific

TABLE 5-3. KEY ECOSYSTEMS REMOTE SENSING-RELATED CONTRACTUAL EXPERIENCE IN THE FOREIGN MARKET

TITLE	CLIENT	DESCRIPTION
Experimental Training in Remote Sensing	United Nations	Training of representatives from 17 selected countries in remote sensing crop forecasting techniques
Agricultural Inventory	ITALECO SPA	Production of thematic map and agricultural inventory of Northern Italy.
Hydrologic Model Florence, Italy	Region of Tuscany	Development of a hydrologic model for Florence, Italy, which utilized LANDSAT imagery to determine land cover parameters
Flood Plain Mapping	United Nations	Development and application of a remote sensing based model for flood plain mapping.
MAF	ITALECO	National Italian inventory of wheat, corn, forage by LANDSAT.

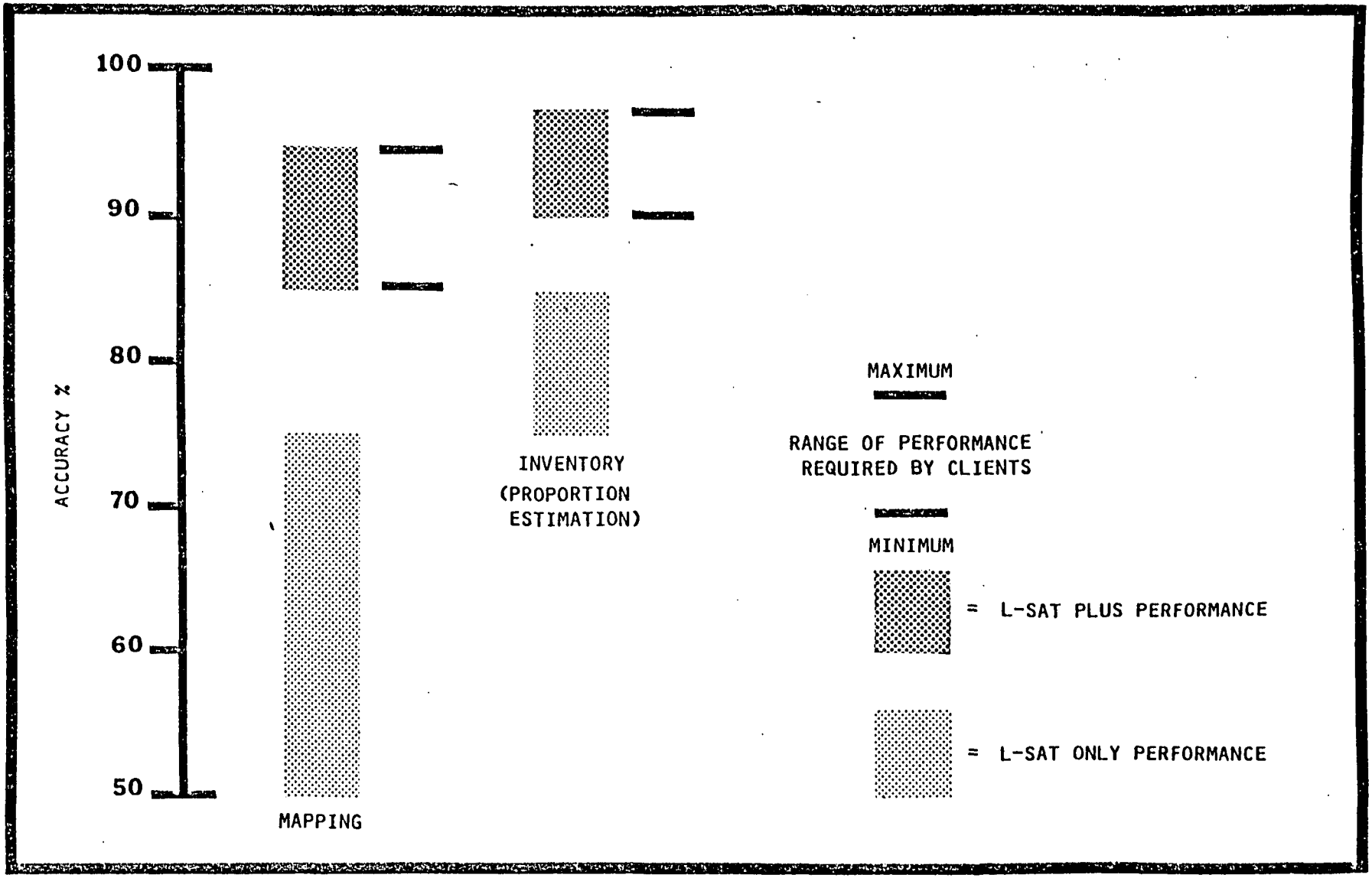


Figure 5-2. Commercial Marketability L-Sat Performance vs. Requirements

problem faced by a particular customer. However, past experiences indicate that there is also a foreign market for less customized services. A case in point was ECOsystems role in structuring, organization, and direction of an International Experimental Training Course in remote sensing for the United Nations. This course was presented in Rome to seventeen African Nationals active in natural resource management. The focus of the course was crop forecasting techniques utilizing remote sensing and was presented by a team of lecturers from the U.S., U.S.S.R., and Italy. This opportunity and others discussed in the description of the US/AID remote sensing programs demonstrate that some opportunity exists for the domestic service industry in supporting general remote sensing awareness activities in the foreign market.

6.0 CONCLUSIONS

6.0 CONCLUSIONS

6.1 INTRODUCTION

This study has provided a detailed analysis and evaluation of the overall private sector, and has identified some industries and businesses which have the greatest potential for utilizing remote sensing, specifically Landsat derived information. This section will present specific conclusions which must be seriously considered before any attempt can be made by the NASA Technology Transfer Program to involve a greater percentage of the private sector in the Landsat program. These conclusions are organized into three groups as they relate to the remote sensing service industry, the private sector user community, and the potential foreign market.

6.2 REMOTE SENSING SERVICE INDUSTRY

Conclusions pertaining to the remote sensing service industry are presented in the following two subsections. They pertain to the digital analysis services industry and the mapping industry, respectively.

6.2.1 DIGITAL ANALYSIS SERVICES

During the study of the digital analysis service industries some issues arose, both pro and con, that must be considered before NASA begins a technology transfer program with the private sector.

In the late seventies, this service industry has been impacted by the following:

- Poor operational support from the Landsat system, and no assurances of a future Landsat program.
- NASA Landsat programs which have not involved the services industries.
- Competition from the NASA programs.

These limitations have forced several companies out of the digital analysis service industry and those that remain are very reluctant to invest further in this field under current conditions. Fortunately, a

small nucleus of companies does still remain in this field and, with proper support and direction, they would be willing to continue promoting this technology. A positive change in NASA policy toward the private sector, combined with the launch of a new satellite system, Landsat D, will provide significant impetus in revitalizing this critical industry.

6.2.2 MAPPING INDUSTRY

The private sector presently receives about 56% of the money available from government and private mapping budgets to perform the data acquisition, interpretation, and cartography procedures necessary in compiling a large percentage of the nation's maps. This industry primarily consists of the optical/photo interpretation service companies.

This study's analysis of the mapping industry indicates that Landsat data can be used for only a very small percentage of maps now and for the rest of this decade. Future projections into the 1990's indicate only about 3% of the mapping revenues will be affected by Landsat. One possibility that could increase Landsat's role in map making and significantly change this projection is a higher resolution system (10m). Such a system, which is unlikely until at least 1995, could impact roughly $60 M per year of mapping industry revenue, based upon the ROM estimate in Section 3-3. Nevertheless, the Landsat family of satellites will have a very limited affect during the 1980's and early 1990's on the service industries supporting the government/private mapping industry.

6.3 USER INDUSTRIES

The analysis of the user industries performed in this study indicates there are two primary categories: 1) the independent user who has sufficient need, capital, and manpower to provide in-house capabilities to analyze Landsat data; and 2) the user who has some need for the information but lacks the resources to invest in analysis capabilities, and would require support from a digital analysis service company.

6.3.1 INDEPENDENT USERS

The independent user is generally in an industry that has considerable capital and requires information about large geographic areas; thus requiring a significant amount of Landsat data analysis. These industries, or associated service businesses, could invest capital to equip their own in-house facility for analyzing Landsat data. These industries can be divided into those capable of near-term use of Landsat technology (up through Landsat D) and those who will require higher resolution of the longer-term satellite systems of the 1990's.

6.3.1.1 Immediate or Near-term Potential Independent Users. The industries listed below have requirements which Landsat has the greatest potential to support now and through the Landsat D series:

- o UTILITIES:
  - ELECTRIC SERVICES
  - NATURAL GAS TRANSMISSION & DISTRIBUTION
  - COMBINATION UTILITIES (ELECTRIC AND GAS)
- o MINING:
  - CRUDE PETROLEUM AND NATURAL GAS
  - IRON ORES
  - COPPER ORES
  - BITUMINOUS COAL AND LIGNITE
  - SERVICE BUSINESSES
    - oo OIL AND GAS EXPLORATION SERVICES
    - oo METAL MINING SERVICES
    - oo BITUMINUOUS COAL AND LIGNITE MINING SERVICES

6.3.1.2 Long-term (1990) Potential Independent Users. These industries have requirements which, for the most part, require higher resolution satellite data such as that available from the MLA system proposed for the 1990's:

- o Mining Engineering
- o City Planners

- o Bridge Tunnel and Elevated Highway Construction Contractors
- o Site Locators

6.3.2 USERS REQUIRING DIGITAL ANALYSIS SERVICE SUPPORT

This category contains a number of potential user industries that do not require or have the capital to invest in an in-house analysis capability. However, they do require information which can be derived from Landsat. These industries and their service industries can be served by the digital analysis service industry providing the necessary Landsat-derived information. The variety of business types and the large number of establishments involved illustrate the need for a viable, diversified Landsat analysis service industry. Once the technology has been demonstrated and proven useful, it may be feasible to establish independent Landsat analysis capabilities in some of the service industries listed below.

6.3.2.1 Immediate or Near-term Potential Users. These industries presently have the requirements and Landsat has the greatest potential to support now and through Landsat D series

o AGRIBUSINESSES:	SERVICE COMPANIES:	- SOIL PREPARATION SERVICES
- FIELD CROP FARMS		- CROP PLANTING, CULTIVATING AND PROTECTION SERVICES
- LIVESTOCK FARMS		- HARVESTING SERVICES
- FOREST FARMING (a few major corporations in this category could be independent users)		- FORESTRY SERVICES
		- LANDSAT DIGITAL ANALYSIS SERVICES
o CONSTRUCTION:	SERVICES COMPANIES:	- ENGINEERING SERVICES
- HEAVY CONSTRUCTION		- ARCHITECTURAL SERVICES
- GENERAL CONTRACTORS INDUSTRIAL BUILDINGS AND WAREHOUSES		- LANDSAT DIGITAL ANALYSIS SERVICES
- WATER SEWER, PIPELINE, COMMUNICATION, AND POWERLINE CONSTRUCTION		
- HIGHWAY AND STREET CONSTRUCTION		

6.3.2.2 Long-term (1990) Potential Users. These industries' needs will more likely be met when the higher resolution MLA systems are operating in the 1990's:

- o Subdividers and Developers
- o Sanitary Engineering

6.4 FOREIGN MARKET

The foreign market, as defined in this study, consists of US/AID and foreign government contracts that are available to the U.S. analysis service industries to support Landsat programs.

The present contracts from this sector are best suited for the smaller service companies. In fact, if it were not for these foreign contracts, the presently hard hit service industries would find it even more difficult to operate.

This total market is expected to continue to provide about $3-5 million per year in Landsat analysis related contracts through the Landsat D era.

When Landsat D is launched, and as the future Landsat program becomes more operational, it is expected that the foreign market will show a significnt increase in the contract dollars for both analysis support and hardware purchases. It is also expected that a major portion will be available to the U.S. industries.

7.0 RECOMMENDATIONS

7.0 RECOMMENDATIONS

7.1 INTRODUCTION

The recommendations presented here are suggested courses of action that the NASA Technology Transfer program can implement and use for the near- and long-term involvement of the private sector in Landsat technology. If implemented, they should bring about a major change in NASA's relationship with the private sector, and, at the same time, provide mechanisms for greater utilization of Landsat-derived information in various industries.

There are no simple steps which will result in immediate full-scale usage of Landsat technology in the private sector, primarily because of the current status of the Landsat system, e.g., data availability, resolution. However, NASA must implement programs now which will promote greater private sector utilization for Landsat D and beyond.

These recommendations are geared toward, 1) utilization of the digital analysis service industry and, 2) the procedures for preparing and involving a general Landsat user community in private sector industry.

7.2 UTILIZATION OF THE DIGITAL ANALYSIS SERVICE INDUSTRY

For Landsat technology to have a greater influence in the private sector, it is necessary to have various types of service companies available to support many applications. This study has indiciated that the potential exists for numerous industries/businesses, both large and small, to utilize Landsat-derived information if service companies were available to provide it. However, these services will have to provide the needed data and information in a timely manner and at a reasonable cost.

In order to initiate a program of assisting digital analysis service businesses it is recommended that NASA issue R&D contracts for competitive bids. These contracts would be designed for both large and small companies to develop a specialized application service (e.g., agriculture, mineral exploration, utilities, etc.) for specific industrial groups requiring Landsat derived information. Presently, NASA's Landsat R&D contracts are

granted to NASA field centers and universities. However, some of the funding for future R&D contracts should be designated for use to the private sector for developing applications techniques for the analysis of Landsat data to meet the needs of private industries.

These R&D contracts will provide the basic economic foundation to allow service companies to build their capabilities and begin preparing for the Landsat D era. After these establishments are operating and developing new capabilities and techniques, their marketing efforts can become the prime vehicle for transferring Landsat technology throughout many areas of both the private and public sectors.

The Landsat applications to be explored and developed under these R&D contracts should be geared to meet the requirements of the industries identified in Section 4 and 6 as having strong potential for Landsat utilization in the near future. Several of the industries which were determined to have the greatest potential in the Landsat D era, based upon the analysis of their information requirements in Section 4, are the following:

- o Agribusiness (farms and their support businesses)
- o Oil, gas, and mineral exploration
- o Utilities
- o Construction

7.3 USER INDUSTRIES

This report has shown that there are many potential users from the private sector with the apparent need for Landsat information, and who could provide the resources to analyze it. However, many of these potential users are not utilizing Landsat information due to the unreliability of the current Landsat system, and NASA can not rectify this situation until Landsat D's launched.

Therefore, to counteract the present negative feelings toward Landsat NASA must begin immediately re-selling the Landsats of the future. To accomplish this, NASA must seriously participate in conferences and symposia and begin developing additional APT/ASVT with other key industries.

7.3.1 CONFERENCES AND SYMPOSIA

NASA must make a serious commitment to "re-sell" the Landsat program and demonstrate that the future Landsats will provide data and information in a reliable manner. The private sector is not going to invest money and manpower in a Landsat system that continues to function like the present system. Therefore, NASA must reiterate its commitment to the Landsat program, and take aggressive action to convince the private sector that future systems will meet industries' needs.

One mechanism is for NASA to actively participate in a "selling" program for Landsat in as many conferences, symposia, and conventions in the next two years. The meetings selected should involve the important industries which have been identified as having potential requirements for Landsat D data and information.

In addition, trade associations may provide a method of approaching these representative industries. Although these associations are primarily lobbyist groups, some may be willing to coordinate activities between NASA and desired industry groups. Table 7-1 lists a few associations in the Washington, D.C. area that could be contacted.

7.3.2 SELECTED APT/ASVT

NASA is presently supporting the private sector on a limited basis. However, one of the more successful projects is an APT with the St. Regis Paper Company. Because of the success of this project, it is recommended that additional, similar type APT/ASVT projects be considered for key companies in the important industries.

Some industries to consider for the near-term technology transfer activities are shown in Figure 7-1.

As the technology is developed and transferred to key industries NASA should work aggressively to sponsor joint symposia to let others in the private sector become aware of what has been accomplished, and continue follow-up work within that industry to assure further transfer to other industries.

TABLE 7-1

TRADE AND AGRICULTURE ORGANIZATIONS

American Mining Congress
1100 Ring Blvd.
1200 18th St. NW
Washington, D.C. 20036
(202) 331-8900

National Coal Association
1130 17th St. NW
Washington, D.C. 20036
(202) 463-2625

American Petroleum Institute
2101 L Street NW
Washington, D.C. 20037
(202) 457-7000

Independent Petroleum Assoc. of America
1101 16th St. NW
Washington, D.C. 20036
(202) 857-4722

American Gas Association
1515 Wilson Blvd
Arlington, VA 22209
(703) 841-8400

Edison Electric Institute
1111 19th St NW
Washington, D.C. 20036
(202) 828-7400

Associated General Contractors of America
1957 E St. NW
Washington, D.C. 20006
(202) 393-2040

Agricultural Research Institute
2100 Pennsylvania Ave., N.W.
Washington, D.C. 2037
(202) 659-2517

National Council of Farmer Cooperatives
1800 Massachusetts Ave., N.W.
Washington, D.C. 20036
(202) 659-1525

Agriculture Council of America
1625 I St., N.W.
Suite 708
Washington, D.C. 20006
(202) 466-3100

INDUSTRY	TARGET	WHY	WHEN	HOW
ELECTRIC SERVICES (U)	LARGE UTILITIES WESTERN U.S. & LANDSAT SERVICE INDUSTRY	• LARGE $ MULTIPLIER • LARGE RESOURCE INFO NEED	APT/ASVT (FY 82) START IMMED.	FOCUSED, COMPETITIVE CONTRACT WITH LANDSAT SERVICE INDUSTRY. LEAD INTO EXPANDED APT/ASVT.
FIELD CROPS (A)	AGRICULTURE SERVICE INDUSTRY - CROP INSECT/DISEASE CONTROL SERVICE	• FIELD CROPS - LARGE AGGREGATE $ & INFO NEEDS. • AGRICULTURE SERVICE COST EFFECTIVE TO ADDRESS TOTAL FARM SECTOR	APT/ASVT (LATE FY 82) (EARLY FY 83)	• DETAILED MARKET STUDY (KEY LANDSAT PRODUCTS. • UTILIZE AGRICULTURE ASSOC. & CO-OPS. • NASA INFOR CAMPAIGN - BASED UPON PRESENT TECHNIQUES AVAILABLE. • GUIDED DEVELOPMENT OF LOW COST H/W AND S/W PACKAGES. UTILIZE AGRICULTURE SERVICE INDUSTRIES & LANDSAT SERVICE INDUSTRIES IN APT/ASVT.
BITUMINOUS COAL (P)	MINING SERVICES & EXPLORATION INDUSTRY INDUSTRY	• LARGEST UNSERVED SEGMENT IN MINING	APT/ASVT (LATE FY 83)	• CONFERENCE/SYMPOSIUM - TO UNDERSTAND NEAR TERM NEEDS. • COMPETITIVE CONTRACTS TO LANDSAT SERVICE INDUSTRY. • DEVELOP ASVT/APT WITH MINING SERVICE AND EXPLORATION INDUSTRIES.

Figure 7-1. Industries for Near-Term Technology Transfer Activities

INDUSTRY	TARGET	WHY	WHEN	HOW
HEAVY CONSTRUCTION (S)	ARCHITECTURE & ENGINEERING WITH LSAT INDUSTRY SUPPORT	• ARCHITECTURE & ENGINEERS CREDIBLE TO CONSTRUCTION	POST THEMA-MAPPER DUE TO RESOLUTION REQ'S.	• IDENTIFY KEY TARGETS FROM TECH. TRANSFER A&E STUDY • CONFERENCE/SYMPOSIUM - PRESENT NASA PLAN & PROJECTED PERFORMANCES. • COMPETITIVE CONTRACTS OF LANDSAT SERVICE INDUSTRIES AND A&E SERVICES.

Figure 7-1. Industries for Near-Term Technology Transfer Activites (cont.)


OAO
CORPORATION